Menlo Park Notebook #12 [N-78-12-20.1]

This notebook covers the period December 1878-January 1879. Most of the entries are by Francis Upton. A few are by Charles Batchelor. All of the material relates to experiments on electric lighting. Included are notes and calculations on filament experiments; notes, drawings, and calculations on generators; and calculations on electric power distribution systems, with comparisons to gas lighting. On page 198 is a table on the cost of electric light, calculated for varying numbers of lamps per day, month, and year. The book contains 284 numbered pages.

Blank pages not filmed: 46-47, 260-261.

No 12

LIBRARY OF THE

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120 BROADWAY, NEW YORK.

Gen'l Library
GENERAL ELECTRIC
Schenectady N.Y.

_____, 189_.

6/40
.86 Horse power
for magnets
proportion of

1 H.P. for friction
1 HP for ~~current 1 lamp~~ Coil
2 HP in all
proportion of 8 per HP $\frac{1}{2}$

Double
6 ub
HP

0 0 0 0 0 0
0 0 0
0 0 0 0
0 0 0

No 12

6/40 Horse power
.86 for magnetic proportion of

1 H.P. for friction
1 HP for ~~current flow~~ p. Coil
2 HP in all
proportion of 8 per HP

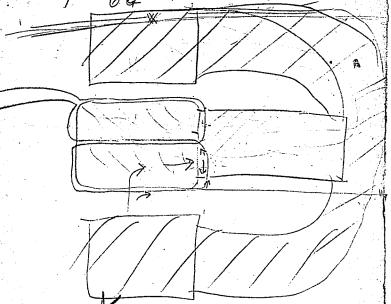
$\frac{1}{2}\frac{5}{8}\frac{2}{8}\Big|\frac{1}{4}$

$\frac{1}{2}\frac{5}{8}\frac{2}{8}\Big|\frac{1}{4}$

8 : 10 5 . 10 : 13 : 5

5 | 50 (5) 6¼

10 | 65 (5) 6½



Attempt at
non commutator

Electric light — Dec 20 1911

Friction preventer — Charles Patchell

Wm A. Force

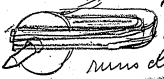
If you put a magnet over the top of a shaft to lift it up and take the weight off it will it run longer with given amount of energy?

Weight & thread	Without magnet	With
1 —	6 ½ seconds	9 ¾
2 —	7 ¼	10
3 —	7 ½	9 ¼
4 —	8	10
5 —	8	9 ¾
6 —	8	10
7 —	8	10
8 —	8	10 ¼
9 —	8 ¼	10
10 —	8	10 ¼
	10 / 77.50	10 / 99.75
Mean	7.75	Mean 9.95

Electric Light Dec 20th 1878

Friction generator of

Large magnet



$\frac{1}{32}$ from shaft

runs down in 10 seconds

~~[illegible] from shaft~~ In this case the magnet held it up itself so that to feel the shake in shaft you have to pull it down

Same magnet $\frac{1}{2}$ inch from shaft

1	—	$9\frac{1}{4}$	seconds
2	—	$9\frac{1}{4}$	~~5~~
3	—	$9\frac{1}{4}$	—
4	—	9 1/2	—

Same magnet $\frac{1}{4}$ inch from shaft

1	—	10	—	4	—	9	—
2	—	10 3/4	—	5	—	10	—
3	—	11		6	—	10 1/4	—

~~4~~ 7 now all the bearings

Friction, prevention of

Same magnet to work
away where you can push
shaft to top or bottom
& then run it
20 seconds or
$2\frac{1}{2}$ times the length of steel
without magnet

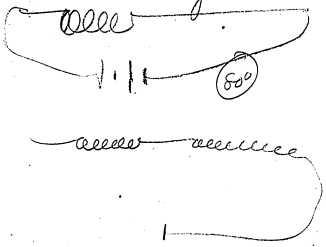
Running 45-0
Gramme machine Ex with batt.

Gramme machine 3 cells
~~cells~~ carbon Batt. 45-0
Bradley. When assisted
is turned in same direction,
the current can be brought
to zero and then there
is no sparks by turning it
further deflection in the
opposite direction.

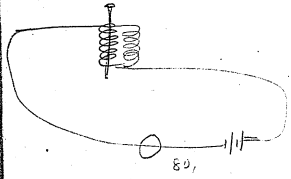
80°

80°

Current diagram



Current diagram



10 10

-0 11

12

$\frac{1}{4}$ 36

		12	
		6	
6	2	3	3/2
3	4	1	3
	8	1/2	
	16	3/4	
	32	3/8	
	64	3/16	

~~800~~

~~400~~

~~6400~~

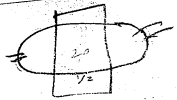
2000 1000'

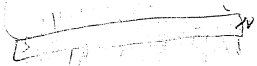
5000°c

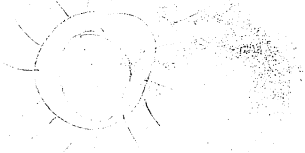
11000.

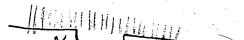
12500
47175

23

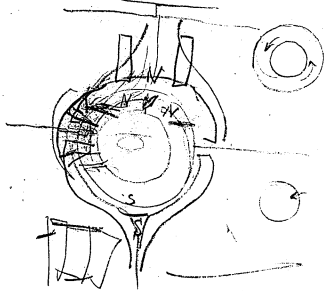


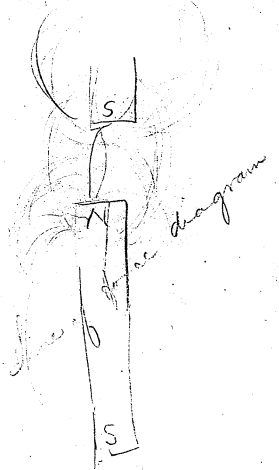


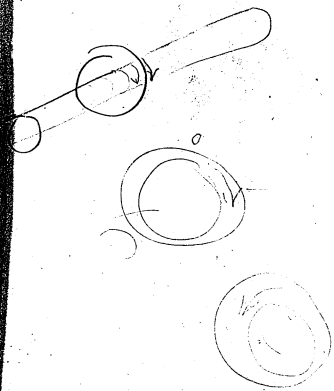




Gramme diagram

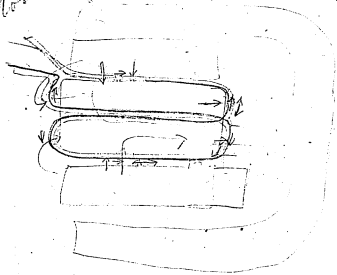



S
N
S

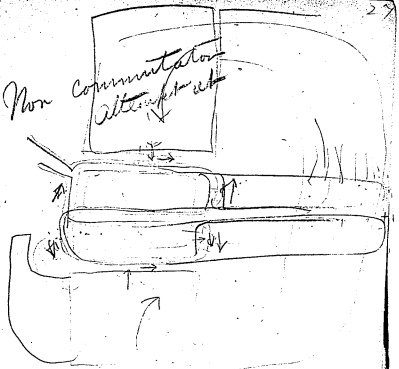


Non commutator attempt

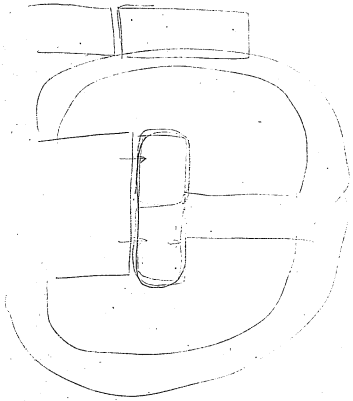
Non commutator attempt at

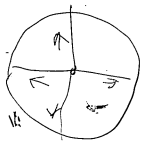


Non commutator

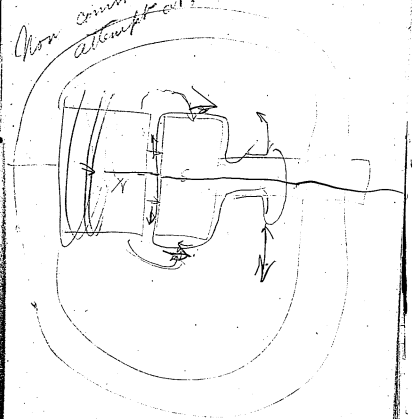


Non commutator
attempt at

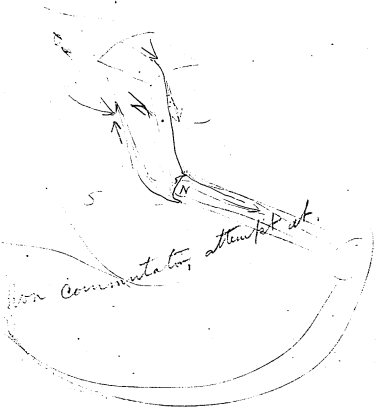




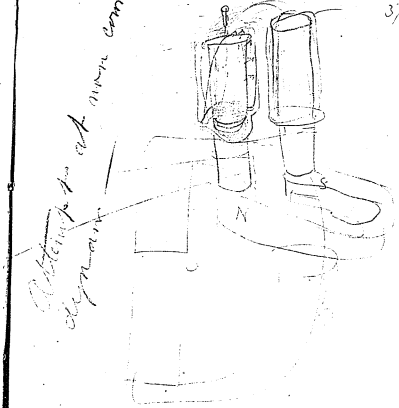
Non commutator, attempt at.



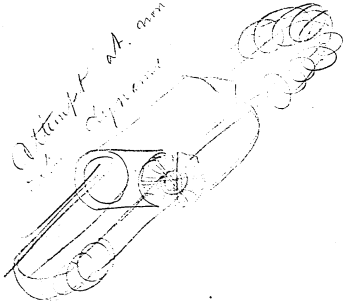
Q
Attempt at


N
S
Non commutator, attempt at.

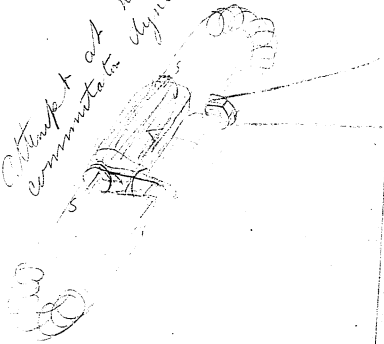
Dynamo machine.
N
S


S
N

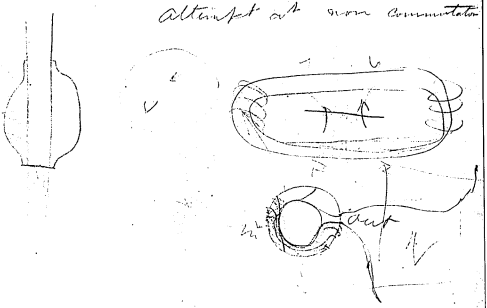
Attempt at a non commutative Algebra

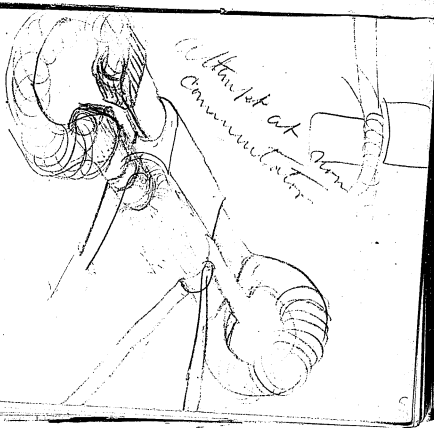


Attempt at a non commutative Algebra.

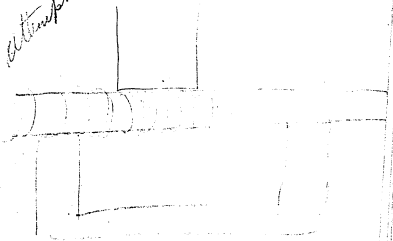


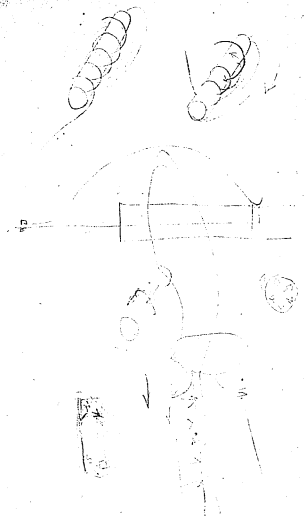
attempt at non commutator

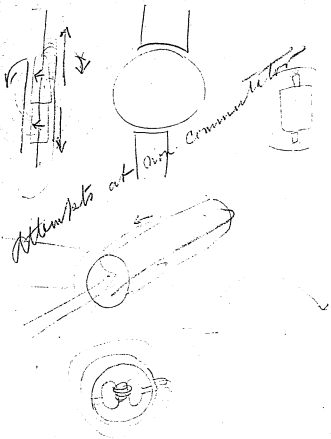




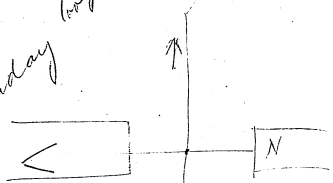
attempt at main commutator





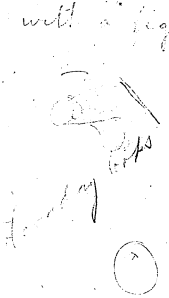

Attachments at end of commutator

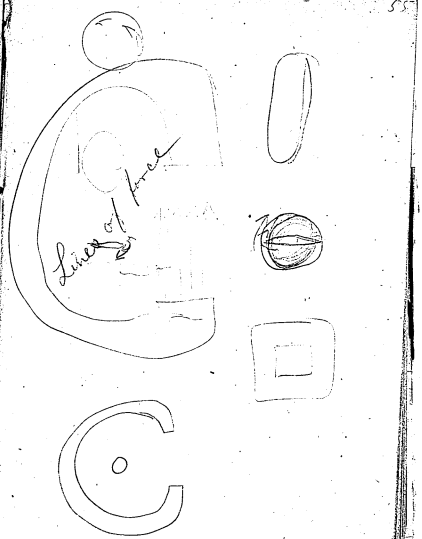
Faraday loops

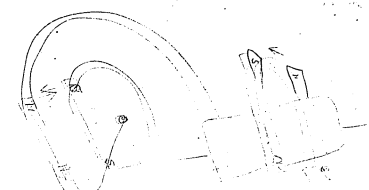


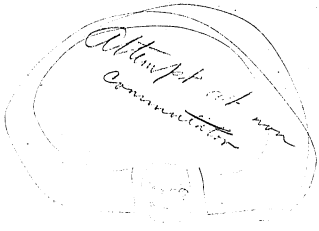
Sunday hooper

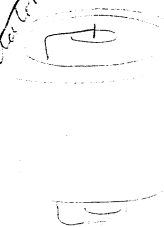
Wound a magnet with a figure 8 worked

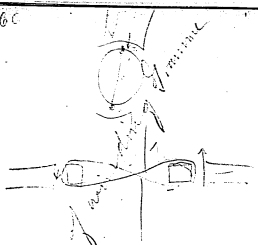




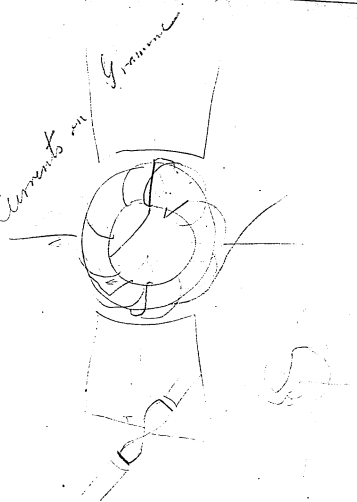



Attempt at a new commutator

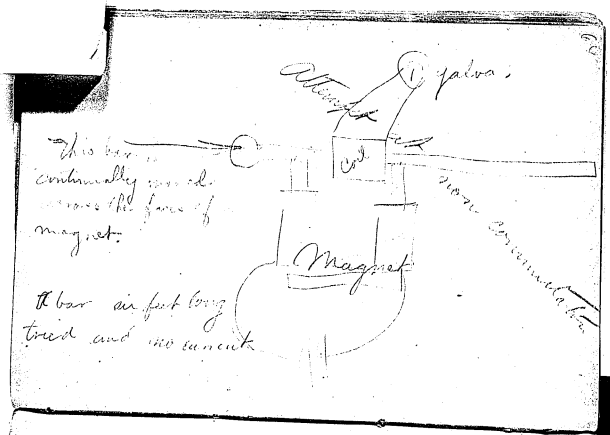



Gymnase
Plan général

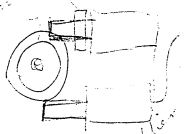
Gymnase


Gymnase
Clairvaux

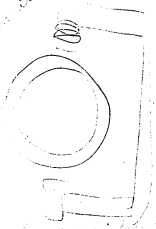
Communicator
Attempted site


galva.
Aluminum
Coil
Magnet
This bar is continually moved, between the faces of magnet.
A bar six feet long tried and no current

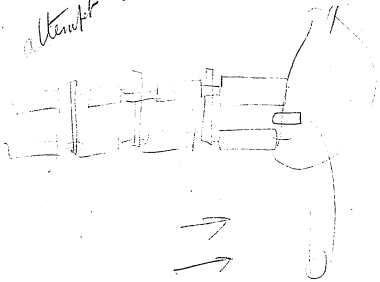
Attempt at a machine for magnetizing magnetism



Attempt magnetic [illegible]



Attempt at non commutator



Attempt for Hexagonal multiplier

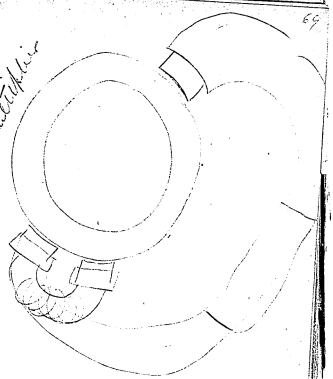
12) 500 (41.25
45
20
12
80
74
60

15) 500
45
50

16) 500 (
32
500
45
20
16
40
32
80
80

31.25

Attempt for Hexagonal multiplier



Rt. Spinal Resistance

Cold 4.6 Ohms Collared

Warm 5 Ohms

Red : 9.3 Ohms

White 12.

4.6) 12 (2.6
9.2
280
276

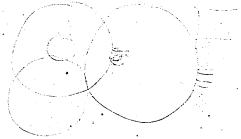
Red 35° 5 Red 9.3 Ohms

9.3

51° 12 Ohms White

Cold

5.6



38.0 Red 4 cells

9.6 Ohms

Instrument 9 cells 52°

13.5 Ohms

9.6 Red

13.5 White

Heat = $C^2 R$ 38.0 Red

.60

.12

.61

12

7.32

.6
4
2.4
9.6
12.0

E in 38° = .78

in 52° = 1.27

.1038
2
.2076

by 1.61 =

1 Internal

1 External

100
100

.78
.78
6.28
5.46
.6084

White 1.61 = C^2

6
4
5.4
13.5
18.9
1.61
15.9
1134
159
30.429

Dull Red 37°

5.35

3 cells of Carbon battery

White 54°5 7 cells of

7.35 Ohm

16
7.35
8.65

10 Cells through 7.35 in coil and 8.65 resistance brought it to equilibrium.

5.35 5
2
16.05.

7.35
3
22.

5.35/7.35

Carbon . 6 . Ohm

$(B + R) = B$ $\quad D$ = deflec

$B + R_1$ ### $\quad$ Resistance D_1 = deflec

$R : B + R_1 :: D_1 : D$ $\quad$ Callaund Upton

$D_1 B + D_1 R_1 = D B$

$B = \frac{D_1 R_1}{D - D_1}$

$D = 42^0$ $\quad B_1 + R$

$R = 2$ Ohm

$\tan 42^0 = .90$

$R_1 = 2$

nat tan $27^0 = .51 = D'$

$$\begin{array}{r} .90 \\ .51 \\ \hline .39 \end{array}$$

$$\begin{array}{r} 51 \\ 2 \\ \hline 39\,\big)\,1.02\,\big(\,2.6 \\ 78 \\ \hline 240 \\ 234 \\ \hline 60 \end{array}$$

Red

78

4 cells give 38°

Coil 9.6 Ohm Resistance pt Acid

Heat = $C^2 R$

Can 38° .78

$(.78)^2 = .61$

each cell

$$\begin{array}{r} .61 \\ 12 \\ \hline 7.32 \end{array} \qquad \begin{array}{r} .6 \\ 4 \\ \hline 2.4 \\ 9.6 \\ \hline 12.0 \end{array}$$

White Heat

79

9 cells give 52°

Coil 13.5 Ohms

Heat = $C^2 R$

Can 52° = 1.27

$(1.27)^2 = 1.56$

$$\begin{array}{r} 1.27 \\ 1.27 \\ \hline 889 \\ 254 \\ 127 \\ \hline 1.5129 \end{array}$$

$$\begin{array}{r} .6 \\ 9 \\ \hline 5.4 \\ 13.5 \\ \hline 18.9 \end{array} \qquad \begin{array}{r} 18.9 \\ 1.56 \\ \hline 1134 \\ 945 \\ 189 \\ \hline 29.484 \end{array}$$

$$7.32 \overline{)29.48} \; (4$$
$$29.28$$

Jan 10 1879

Red 37° 3 cells

Coil 5.35 ohms

$a^2 R$

9.877
9.877
19.754
.854
20.608

.6
3
1.8
5.35
7.15

.608 = long 4.06

White 54.5 7 cells

Coil 7.35

10.146
10.146
1.060
21.352

.352

.6
7
4.2
7.35
11.55

22.5

4.06) 22.5 (5
20.3
2.20

~~2 cells brings it red~~

4 cells 38°

Coil ~~9.6~~ 4.9 9.6

~~9.892~~

~~log 5 9.892~~

9.892	9.892
9.892	9.892
.698	.982
20.482	20.766

~~9.~~

9 cells 52°

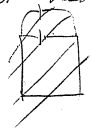
~~Fr 3~~

Coil 13.5 log 135

~~log 13.5~~

10.107	10.107
10.107	10.107
.032	1.170
20.946	1.284
.482	.766
.464	.618

4.15 more heat given off at mean diameter than at Red heat.



2 cells 36°

Coil 4.9

C =

log tan 37° 9.877 log tan 54.5 10.146
9.877 10.146

log 5.35 .728 log 7.35 .866
20.482 21.258
.482
.776

5.96

2 cells

6
14.7
log 4
9.8

C = 6 / 4.8 + 4.9

2 nunc cells
4.9

Spiral run Jan 10

Cut 7 35 Ohms

Rise 5

Cells 4.8 17.15

$\Delta J =$ 18°

9.511
9.511
log 7.35 .866
19.888
7.74

Cut

Cut 5 Ohms

Rise 14

4.8

Cell 24.8

9.288
9.288
.698
19.274

$\Delta J =$ 11° 1.888

Jan 10 Shunt not known

18
18
144
18
324
7.35
1620
972
2268
2381.40

11
11
121
605

4 times more work for meanderings than for rest

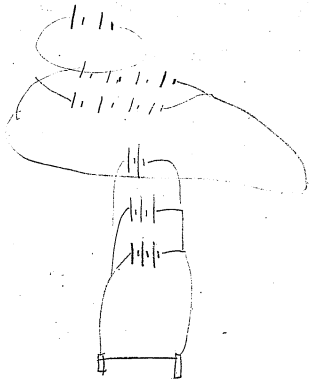
605) 2381 (3.9
1815
5660
5445
1150

1.88 (8).888
.274
614

4.1

Red new Spiral
5.2 Ohms

Incandescent
7.3



11) 3.3

.3

8) 4.4

.55

10) 4.4

.44

12) 4.4

.36

14) 4.4

42

150 min very dull red 91

~~D = 6° 15'~~

Dull red

D = 12°

R = 69

Again

D = 11° 30

R = 7 Ohms

Dark

~~Bright red~~

Orange red

13° 15'

7.7 Ohms

13° 15'

7.7 Ohms

~~12500~~

Yellow in the dark

N = 15° 45'

R = 8.4 Ohms

N = 16°

R = 8.9

~~Bright~~ Yellow

$\Delta = 13°$
$R = 9.2$

Red same as that of iron lamps.

$\Delta = 14° 25'$
$R = 8$ Ohms

9.4100
9.4100
.9030
19.7230
7.7230
7.3894
2.16 .3336

14 cells full "[illegible]"

A = 20° 30'
R = 1[illegible]

20° 15'

9.5669
9.5669
1.0606
2.01944

D = 20°
R = 11.9

.1944
T 7230
.4714

2.96

.1944
T 3894
.8050

6.39

Lowest red

D = 11°
R = 6.49

9.2886
9.2886
.8122
19.3894
T.3894

98 Of Wire
Another red of spirals

12° 15'
7.4

9.2367
9.2367
.8692
1.9542 6
$\bar{1}$.5426

Incandescent
$\bar{1}$.1944
$\bar{1}$.5426
.6578

4.48

Iron spiral red

21° 30'
5.3 ohms

9.5953
9.5953
.7242
1.9148
$\bar{1}$.9148

.1944
$\bar{1}$.9148
.2796 = log. 1.9

$\bar{1}$.9148
$\bar{1}$.5426
.3722

log 2.35

Spiral red 2.35 times
wire red

wire mean 4.48 times wire
red

2.35
.19
2005
235
4.355

.13 diameter of a spiral
of Pt wire
$\frac{1}{2}$ inch long

~~[illegible]~~ 0.010 wire

.13
3.141
.5

T.1139
.4969
T.6984
699

Rt. Spinal Jan. 15 1899 [illegible]

2 cells dull red

D = 13° 30'

R = 3.1

9.3803
9.3803
0.4913
$\overline{19}.2519$
$\overline{1}.2519$

D = 4 cells

R = 2.66

12

D = 35°
R = 4.96

9.8452
9.8452
.6954
20.3858

.3858
1.2519
1.1339

13.5

Still Red
Differ 14°35'
Resist. 3.36

9.4126
9.4126
.5263
19.3515
1.3515

6.78

D = 29°30'
R = 4.76

9.7526
9.7526
.6776
20.1828

.1828
1.3515
.8313

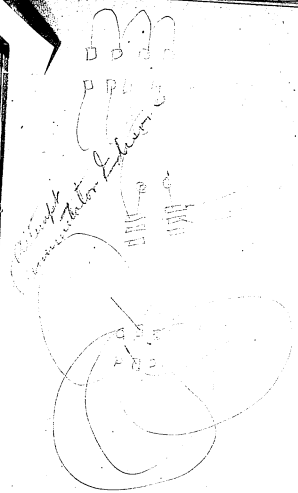
Spiral

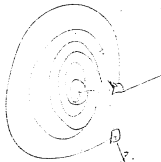
D = 13° 30′ D 28°

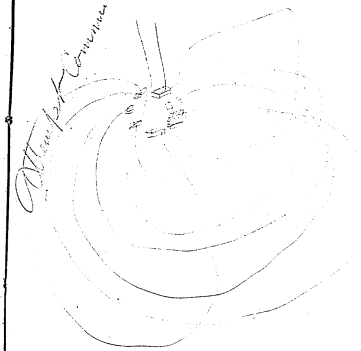
R = 3.53 ch R 5.03

9.3803	9.7347
9.3803	9.7347
.5477	.7015
19.3083	201709
7.3083	-.1709
	1.3083
	.8626

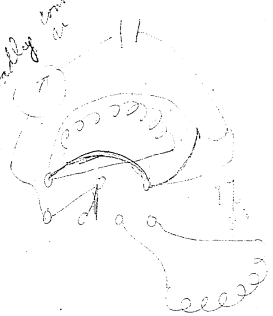
7.29







Bradley's connection



Subdivision of gas jet

6 light on coal cutter tube

H 5·312

1 jet burns 4 ft in 72 min

Intermittent

B

$$\frac{d}{dx}\frac{f(x)}{\varphi(x)} = \cancel{\frac{f(x+h)-f(x)}{\varphi(x+h)-\varphi(x)}}$$

Heat equations

$$\frac{f(x+h)}{\varphi(x+h)} - \frac{f(x)}{\varphi(x)}$$

$$\frac{f(x+h)\varphi(x) - f(x)\varphi(x+h)}{\varphi(x+h)\varphi(x)}$$

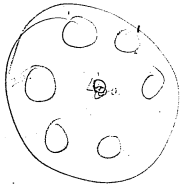
$$\frac{(f(x+h)-f(x))\varphi(x) - (\varphi(x+h)-\varphi(x))f(x)}{\varphi(x+h)\varphi(x)}$$

$$\frac{f'(x)\varphi(x) - \varphi'(x)f(x)}{(\varphi(x))^2}$$

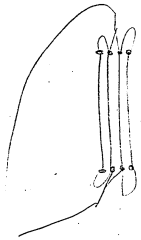
$$\frac{d\,\dfrac{\varepsilon^2 n l}{(\rho + r + n l)^2}}{d(nl)} =$$

$$\frac{dH'}{dnl} = \frac{\varepsilon^2(\rho + r + nl)^2 - 2\varepsilon^2 nl(\rho + r + nl)}{(\rho + r + nl)^4}$$

$$= 0$$

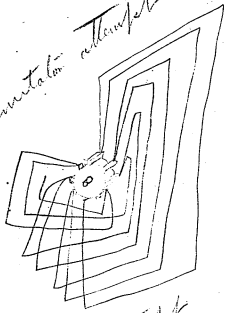


Mr. Preece in the Phil. Journal for Jan. 1879 makes a

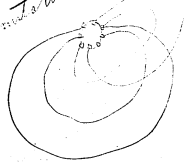


Commutator attempt

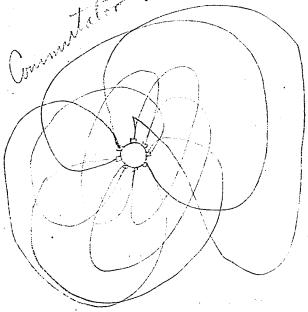
Commutator attempt



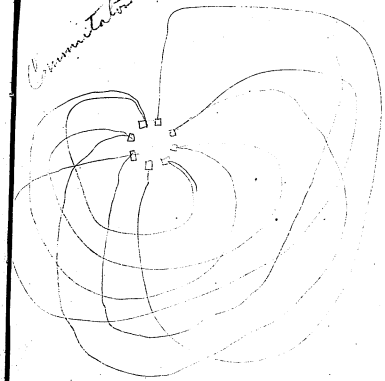
Commutator attempt

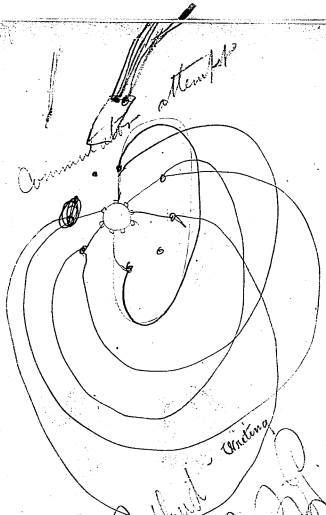


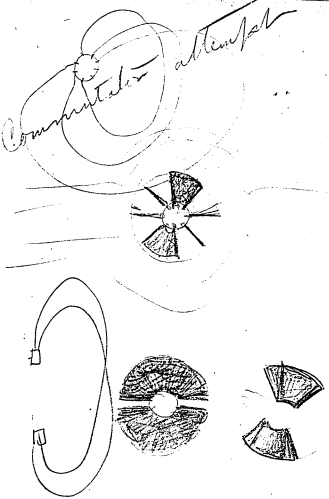
Commutator attempt



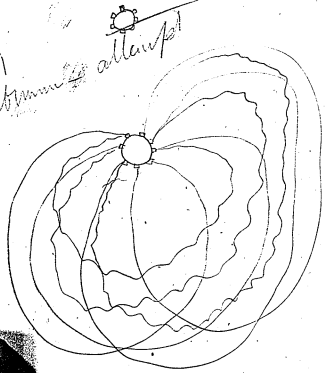
Commutator attempt



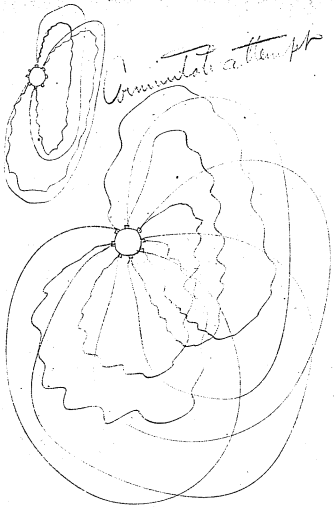

Commutator attached
Winding


Commutator attached

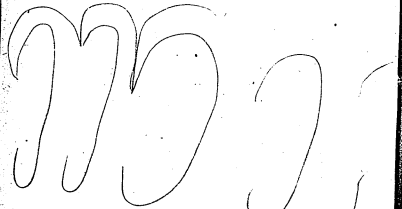
Commutative attempt



Commutative attempt

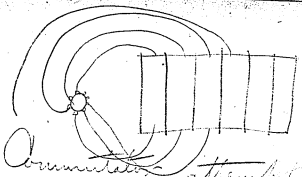


Commutator attempt

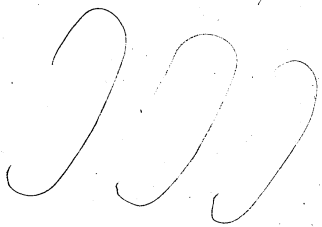


$C = CR^2$ $\quad$ $H = C^2 R$

$C = \frac{E}{R}$ $\quad$ $H = \frac{E^2}{R}$



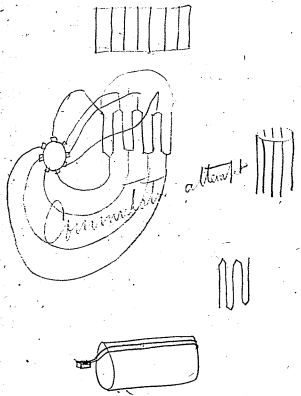
Commutator attempt

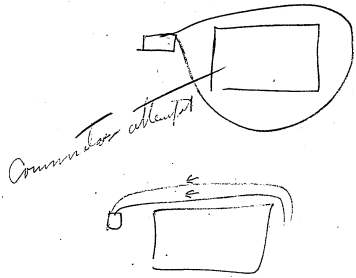


~~4000~~ 1000 / 8 = .125

2000 / 500 = 1570 / 1166

750) 600
150) 100
392
64


Commutator attempt


Commutator attempt

$$H' = \frac{\mathcal{E}^2 n l}{(\rho + r + n l)^2}$$ in series

$x = \frac{\mathcal{E}^2}{R} = c^2 R$ $\quad \frac{c^2}{R}$

$$H'' = \frac{\mathcal{E}^2 \frac{l}{n}}{\left(\rho + r + \frac{l}{n}\right)^2}$$ multiple arc

$x = (\rho + r + \frac{l}{n})^2$

$\rho + r = 5$ ohms $\quad \mathcal{E} = 1$

$l = 500$ ohms

$$H'' = \frac{500}{(5.0 + 500)^2}$$ $\quad n = 1$ lamp

$$= \frac{500}{\quad}$$

2.6989
5.4064
3.2925

Log 505 = 2.7032
2.7032
5.4064

.00196

$n = 2$ ~~Tend~~ Temp of Wire 17

$$H'' = \frac{250}{(5 + 250)^2}$$

2.40654
2.40654
4.81308

2.39794
4.81308
3.

.03840

505) 5000 (9

500
5000
(1000)

250

505
505
2525
2525
2500 R 5

500 / (505)²

2.70329
2.70329
5.40658

2.698897
6.40658
$\bar{3}.29239$

.00196

---

250 / (255)²

2.40651
2.40651
4.81302

2.39794
4.81302
$\bar{3}.58472$

2 / .003840
.00192

---

125 / (130)²

2.113943
2.113943
4.227886

2.096910
4.2778
$\bar{3}.8291$

4 / .00646
.00161

$n = 4$

625 / (67.5)²

1.8293
1.8293
3.6586

1.7958
3.6586
$\bar{2}.1372$

8 / .0137 =
.00172

$n = 16$

30

$$H = \frac{\mathcal{E}^2 \cdot \frac{l}{n}}{\left(\rho + r + \frac{l}{n}\right)^2} \qquad \mathcal{E} = 1$$

$\rho + r = 5$ ohms

$l = 500$ ohms

$n = 1$ $\quad \frac{l}{n} = 500$ $\quad$ ~~100:1~~ ~~$100:1$~~

$\rho + r + \frac{l}{n} = 505$ $\quad$ 1 lamp

.001965

log 2.698970 $\quad$ 2.703291

5.406582 $\quad$ 2

3 .292388 $\quad$ 5.406582

2256

132

= log .001965

$n = 2$ $\quad \frac{l}{n} = 250$ $\quad$ ~~100:1~~

$(\ ) = 255$ $\quad$ 2 lamps

1923

log 250 $\quad$ 2.397940 $\quad$ log 255 $\quad$ 2.406540

4.813050 $\quad$ 4.813080

3 .584850 $\quad$ 2/003847

7783 $\quad$ .001923

0077

13

$n = 3$ $\quad \frac{l}{n} = 166.6$ $\quad$ ~~100:1~~

$(\ ) = 171.6$ $\quad$ 3 lamps

.001881

log ~~2.1675~~

2.221675 $\quad$ 2.234517

152 $\quad$ 152

13 $\quad$ 15

1

2.221848 $\quad$ 2.234685

4.469370 $\quad$ 4.469370

3 .752458

37

3/.005685

.001884

.001881

$n = 4$ $\quad \frac{l}{n} = 125$ $\quad$ ~~100:1~~ ~~$100:1$~~

$(\ ) =$ ~~132~~ 130 $\quad$ 4 lamps

1849

2.096910 $\quad$ 2.117271

~~4.234562~~ $\quad$ 4.234562

3 ~~.862368~~ $\quad$ ~~2.120574~~

~~4.241143~~

24/007284

.001821

2.096910

~~4.241143~~

~~3.855763~~

~~4/00 11774~~

~~.001793~~

4/00 7 3984

001849

2.096910

4.227886

3.869124

7

2.113943

2.113943

4.227886

$n = 8$ $\quad \frac{l}{n} = 62.5$!

100 : 1 $\quad (\ ) = 67.5$!

1.795880
3.658608
2.137272
7037
.006135

1.829304
3.658608

8 / .013714
.001714

$n = 10$ $\quad \frac{l}{n} = 50.$ $\quad$ 100 : 1

$(\ ) = 55.$

1.698970
3.480726
2.218244
8010

1.740363
3.480726

10 / .016572
.001650

log 50 1.698970
amplifying .5 8.25963
.55 8.25963
10 9.
.01653 3.218244

$n = 12$ $\quad \frac{l}{n} = 41.75$

100 : 1 $\quad (\ ) = 46.75$

1.620656
3.339564
2.281092
1033
59

1.669782
3.339564

12 / .019102
.001591

$n = 16$

$\frac{n}{2} = 31.25$ $\quad n = 16$

100 : 1

$(\ ) = 36.25$

1.494850
3.118616
2.376234
12
22
1.204120
3.172114

1.559308
3.118616

16 / .023781
.001486

20 lamps $\frac{\rho l}{h} = 25$ $\frac{500}{2\rho} = 25$

100 : 1 $( ) = 30$

.001388

1.897940
2.582724
2.815216
179
37

1.397940
2.954242
2.443698
3576
122

~~1.497362~~
~~2.582724~~
~~.065534~~
.003

1.477121
2.954242
.027778
.001388

21 lamps $\frac{\rho l}{h} = \frac{600}{21}$

100 : 1

1365

2.698970
1.322219
1.376751
3577
174

$\rho + r = 5$

23.809
5
28.809

1.376751
2.919054
2.457597
79
2858
2.457597
1.322219
3.135378

1.459392
35
1.459527
2.919054

.001365

25 lamps

$\frac{l}{n} = 20.$ 100 : 1

$(\rho + r + \frac{l}{n}) = 25$

1.361030
2.795880
3.505250
1.397940
3.107310 = log .001283
210
100

log 25 1.397940
1.379780
2.795880

30 lamps $\frac{l}{n} = \frac{500}{30} = 16.66+$

100 : 1 $(\rho + \frac{l}{n}) = 21.66+$

1.221675
157
15
2
1.221849
2.671584
2.556265
2.5
37

1.335658
120
12
2
1.335792
2.671584
36.035503
.001183

136

35 lamps : $\frac{500}{35}$

40 Lamps $\frac{\cancel{R}}{n} = \frac{500}{40} = 12.5$

100 : 1 $(15 + \frac{5}{2}) = 17.5$

1.096910
2486076
2.610734
660
74.

1243038
2486076

.0040806
.001020

50 lamps $\frac{500}{50} = 10$

100 : 1 $(15 - \frac{5}{2}) = 15$
15
9.5
2.45.

$\frac{100}{245}$

log 1.
2.389166
2.610834
660
70

50 | .0408167
.000816

137

log 10	1.
comp log 15	8. 823909
log 15	8. 823909
50	8. 301030
	4. 998848

.000816

$$\# = \frac{\varepsilon^2 \frac{l}{n}}{(\rho + r + \frac{l}{n})^2} \qquad \varepsilon = 1$$

$\rho + r = 1 \qquad l = 500$ Ohms

1 Lamp 500 : 1

500 — 2.698970

$(501)^2$

2.698970
5.399676
3.299294
89
5

2.698970
5.399676
.001992

3 lamps $\frac{l}{n} = 166.66+$

500 : 1 $\quad (1+\frac{l}{n}) = 167.66+$

2.221848
4.445780
3.776068
47
21

2.222846
156
16
2
2.222898
4.445780

3|6059713
.001990

10 lamps $\frac{l}{n}$ 50

500 : 1 $\quad (1)$ 51

1.698970
3.4151 40
2.283830
3753
77

1.707570
3.415146
01922
.001922

15 lamps $\frac{l}{n}$ 31.25

500 : 1 $\quad +1$ 32.25

1.494850
3.017060
2.477790
700
1.204120
3.273670
464

1.508580
3.017060
300 4
.001877

15|500 @ 125
45
50
15
40

20 lamps 25
26

log 26 = 1.397940
log 26 1.

146

~~25 lamps~~ 20 500/25

21

1.301030
2.606392
2.694638
1.397940
3.296698

1.303196
2.806392
1814

25 lamps

log 20 1.301030
log 21 1.322219
2.444438
2.656592
1.397940
3.258652
37

500 : 1

40 lamps 12.5 – 13.5

log 12.5 = 1.096910
log 13.5 = 1.130334
2.266668
2.426242
1.602060
3.234182
1715

500 : 1

80 lamps 500/250 = 1

log 6.25 = 0.795880
log 7.25 = 9.139662
80 = 9.096910
3.172114

1486

50 lamps 60 lamps 141

log 10 = 1.
11 = 1.041393
2.958607
1.041393
2.082786
2.917214
1.698970
3.218244

~~25 lamps~~ 60/40 = 1.5
~~25 lamps~~ 60/50 = 1.333
log 8.333 = 0.920645
7.333 = 0.865882
8.939764
2.980880
1.378151
.01594 3.202729

.01652

60 lamps .01594

80 lamps 8.50 6.25

log 6.25 0.795880
7.25 0.860338
1.920676
2.875264
1.903090
1.972114

1486

~~80 lamps~~

5. 3)5.0 (1.3
6. 3
140
108
320

500 : 1

1486

1.556303
1.443697
2
3.443697

.698970
1.556303
1.142667
2
3.142667

~~140 lamps~~ .00380 500 : 1

142

90 lamps

9 ⟌ 50

5,555

log 5.5557 0.744293

6.5554 0.8

500 : 1

579
37
610

.744684
39
4

.744727
.816610
.1633220
$\bar{1}.111507$
$\bar{1}.954243$
$\bar{3}.157264$

.001436

8 ⟌ 50

6.25

7.25

0.795880
0.860338
1.720676
$\bar{1}.075204$
1.903090
$\bar{3}.172114$

.001486

100 lamp 500 : 1

.001386

1000 143

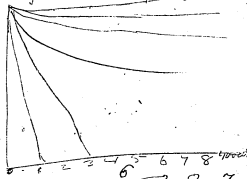
$\frac{l}{n}$

$l = (\rho + r + \frac{l}{n})^2 \rho + r$

$l = 2000$

$l = 1000 \ (\rho + r)$

$l = 500 \ (\rho + r)$



$\frac{l}{n}$

$(\rho + r + \frac{l}{n})^2$

$\frac{l}{n}$

$(\rho + r + \frac{l}{n})$

$\frac{l}{n}$

$(\rho + r + \frac{l}{n})^2 \rho$

$r + \frac{l}{n}$

$\frac{l}{n}$

$(\rho + r + \frac{l}{n})$

2500

~~4000 to one~~

Four thousand to one.

i.e. 4000 Ohms in lamp 1 in st.

1000 ohms in lamp $\frac{1}{4}$ in machine

1 lamp $\frac{e}{n} = 4000$

$= 4001$

25 lamps $\frac{e}{n} = \cancel{4000}$ 160

161

$\frac{e}{n}$ 4000

500 500. 1 Lamp 4000 : 1

~~4000~~

500.

500.125

2.698970	2.698970
+.096910	2.699077
2.795880	5.398154
	3.300846

.001999

50 lamps 4000 : 1

10 ohms

50 ~~500~~

10

10.

10.125

1.	
1.005999	
2.011998	
2.988002	
1.698970	
3.289032	

.1990

~~1000~~ 100 Lamps 4000 : 1

~~100~~ 100 lamps $\frac{e}{n} = 5$ lamp = 500

$.125 + \frac{e}{n} = 5.125 + r = .125$

$= 5.125$

log 5 = 0.698970

5.125 = 0.709699

1.419388

1.279582

2

3.279582

.001903

Lamp 1p Ohmy 1:1
Lamp 500 ohms
$\rho + r = 500$ 1 lamp

$$\frac{1}{Q} \quad \frac{500}{500+500} = \frac{1}{500} = .002000$$

$$\frac{500}{1000000} = \frac{5}{10000} = .00050$$

2 lamps

15	
1.5	
.15	
log 250	$\bar{1}.698970$
comp log 1.5	9.823909
1.5	9.823909
2.	9.698970
	1.045758

$\bar{1}.698970$
0.176091
$.352182$
$\bar{1}.364788$
$.301030$
$\bar{1}.045758$

2 | 11.08 / 11620

500 | .0581
.00011620

250 | .0581
500 | 11620
.000232

250

250	2.397940
comp. 750	$\bar{3}.124939$
750	$\bar{3}.124939$
log 2	9.698970
	4.346788

2 lamps 1:1

.00224

3 lamps 1:1

166.65	2.221675
666.66	2.823874
	5.646948
	4.574727

.000345
.00125

4 lamps 1:1

125.	2.096910
625.	2.795880
	8.891030
	5.591760
	4.505150

.00020
.00080

500

2 lamps

$\frac{800}{2} = 250$

log 250
comp log 750

$$\frac{250}{(500+250)^2} = \frac{250}{(750)^2} = \frac{1}{9 \times 250} = \frac{5}{(1.5)^2} = \frac{5}{(3 \times .5)} = \frac{1}{9.8 \cdot 115}$$

	2.397940
	$\bar{7}.124939$
	$\bar{7}.124939$
	9.698970
	4.346788

3 lamps
log 166.6

4000 : 1

500 ohms in lamp

.125 ohm = g+r

---

200 lamps

$\frac{l}{n} = 2.5$ 0.397940

.147 $\frac{l}{n} = 2.625$ 0.419129

.838258

$\bar{1}.559682$

200 $\overline{1}.3629$

.0018 14

~~600~~ lamps 4000 : 1

$\frac{l}{n} = 1.25$

.125 + $\frac{l}{n}$ = 1.375

log 1.25 0.096910

.138303

.276606

$\bar{1}.820304$

2.602060

$\bar{3}.218244$

.001653

---

600 lamps 4000 : 1

$\frac{l}{n} = \frac{500}{600} = .833$

.833 .125 +

.958 .833

~~$\bar{1}.920665$~~

~~$\bar{1}$~~

$\bar{1}.920817$

$\bar{1}.981516$

~~3.9344~~

$\bar{2}.963032$

.957785

.778151

.001512 .179634

1000 lamps 4000 : 1

$\frac{500}{1000} = .5$ $\bar{1}.698970$

.125 + .625 $\bar{1}.795880$

$\bar{1}.591760$

.1280 $\bar{1}.107210$

$\bar{5}$

150

1500 lamps 4000 : 1

$\frac{500}{1500} = .3333+$

$.125 \times .3333 = .14583+$

.3333 ~~.32344~~

T. 522875
T. 661178
T. 322356
.200519
3. 176091
$\bar{3}$. 024428

~~.01333~~

.00105-2

2000 lamps 4000 : 1

$\frac{500}{2000} = .25$

$.125 \times .25 = .375$

log .25 T. 897940
log amp .375 10. 425969 −10
" " .375 10. 425969 −10
log amp 2000 6. 698970 −10
26. 948848
30.
$\bar{4}$. 948848

.000 888

2500 lamps 4000 : 1

$\frac{500}{2000} \frac{1}{5} = .2$

log .2 $\bar{1}$. 301030
log amp .325 10. 488117 −10
" " .325 10. 488117 −10
" " 2500 6. 602060 −10
26. 879324
30.
$\bar{4}$. 879324

.000 757

3000 lamps 4000 : 1

$\frac{500}{3000} = .1666$
125
.2916

log .1666+ T. 221675
175
3
log amp .2916+ 10. 537812−10
" " .2916+ 10. 537812−10
" " 3000. 6. ~~522879~~ 10
36. ~~614690~~
30.
4. 814911

~~.000 652~~

653

152

4000 lamps 4000 : 1

$\frac{500}{4000} = .125$

log .125 $\bar{1}.096910$

Compl .250 10.602060 10

.250 10.602060

4000. 6.397940

.000500 $\bar{4}.698970$

4000 : 1

5000 lamps 4000 : 1

$\frac{d}{n} = .1$ $\bar{1}.$

+.125 .225 10.647817

10.647817

5000 6.301030

.000395 $\bar{4}.596664$

6000 lamps

$\frac{d}{n}$ 500 / 60.00 .0833

.0833+ $\bar{2}.920645$

.2083+ 10.881311

10.681311

6000 6.221849

.000320 $\bar{4}.505116$

8000 4000 : 10,000

$\frac{d}{n} = \frac{5}{80} = .0625$

~~.1875~~

.0625 $\bar{2}.795880$ .05 $\bar{2}.698970$

.1875 10.726999 .175 10.756961

.1875 10.726999 10 10.756961

8,000 6.096910 10000 6

.000222. $\bar{4}.346788$ .000163 $\bar{4}.212892$

3000 : 1

$d = 500$ $\rho + r = \frac{500}{3000} = .1666$

1 lamp $\rho + r = \frac{500}{3000} = .1666$

~~log .1666~~ 500 2.698979

Amp 500.1666 ~~699107~~

" " $\bar{3}.300893$

$\bar{3}.300893$

~~2~~ $\bar{3}.300765$

1996

50 lamps $\frac{d}{n} = 10$ 6894 / 254 / 25 / 5 / 7178

log 10 1. ~~8.778325~~ 1. 8.992822

Compl 10.1666 ~~8.778325~~ 8.992822

50. 8.301030 8.301030

.001935 ~~4.857680~~ 3286674

250 lamps $\frac{500}{2.50} = 2$ 5458 / 121 / 12 / 1

2 0.301030 301030 5592

2.1666 9.66 ~~1407~~ 5592 664208 65 8

2.6666 9.66 ~~4407~~ 664208 12 1

250 7.602060 60 2660 1

5792

~~3.631904~~ 3.231506

~~.1076~~ ~~3.834674~~ .001704

200 lamps 3000 : 1

$\frac{500}{200} = 2.5$

.2666+

2.6666+

log 0.397940

9.736624

9.736624

7.698970

3.570158

.64167

.42

14

1

6624

200 lamps 3000 : 1

$\frac{l}{n} = \frac{500}{200} = 2.5$

$rp + \frac{l}{n} = .1666 + 2.5 = 2.6666+$

log 2.5 0.397940

comp log 2.666 9.574036

2 9.574036

~~200~~ ~~7.30 10 30~~

~~847092~~

7.698970

3.244982

5880

95

9

5864

∴ 1757

500 lamps 3000 : 1

$\frac{l}{n} = \frac{500}{3000} = 1.$

log 1 = 0.

log comp 1.16+ = 9.933048

= 9.933048

comp. log. 500 = 7.301030

3.167126

.001469

8699

228

23

2

6952

1000 lamps

$\frac{500}{1000} = \frac{1}{2}$ 500 .5 2000 .160

$\frac{l}{n} = .5$

.2666+

log .5 = $\bar{1}$.

comp log .2666+ = 10.574900

.2666 = 10.574900

comp log 1000 = $\bar{3}$.

~~.00852~~ = $\bar{4}$.149800

~~.001412~~ $\bar{3}$.

4569

37

4606

$\bar{1}$.678970

5941

10.115977

10.115977

5391

$\bar{7}$.

$\bar{4}$.930512

92952

1500 lamps

log .3333+ $\bar{1}$.522486

comp log 4.999+ 10.301030

.4999+ 10.301030

.1500. 6.823909

4.948955

.000888

1000 lamps

.5 $\bar{1}$.678970

.666+ 10.176093

.666+ 10.176093

1000. 7.

3.052166

.1127

3865

42

3907

Conductors

~~3 lamps~~

25 to 1

1 Lamp $\frac{500}{25} = 20$ $C = 500$

$\rho + r = 20$ Ohms

log 500 2.698970
Amp log 520 7.283997
520 7.283997
3.266964
.001849

2 Lamps 250 500

log 250. 2.397940 2.397940
amp. log. 278. 7.560667 7.568636
278. 7.560667 7.568636
2. 9.698970 9.698970
27.278244 3.234182
3.
~~.001849~~
.001714

3 Lamps 166.66 0912
166.66+ 8.55 139
20 2.221853 14
186.6 7.728935 1
7.728935 .1066
1.728934
9.622879
.322202
3

3 Lamps 25:1

$\frac{500}{3} = 166.6+$

log 166.6+ 2.221854
amp log 186.6+ 7.728935
186.6 7.728935
3. 9.522879
3 2.202603

1595

~~1414~~
~~161~~
~~16~~
~~2~~
~~1593~~
1675
161
16
2
1854
270912
138
14
271065

4 Lamps 25:1

$\frac{500}{4} = 125.$

log 125 2.096910
amp log 145 7.838632
7.838632
4 9.397940
3.171114
2
~~.001490~~
1486

26 : 1

5 lamps

$\frac{500}{5} = 100$

$g + r = 20$

log 100. 2.~~4200~~

colip log 120. 7.920819

120. 7.920819

5. 9.301030

.1389 $\bar{3}.142668$

25 : 1

10 lamps

log $\frac{500}{10} = 50$ 1.698970

complog 70 8.154902

70 8.154902

10 9.

~~$\bar{5}.610834$~~

.0102 $\bar{3}.008774$

25 : 1

16 lamps $\frac{500}{16} = 31.25$

log 31.25 1.494850

colog 51.25 8.290306

51.25 8.290306

16. 8.795880

~~$\bar{3}.071370$~~

~~.00117~~ $\bar{4}.871342$

.00743

16)500 (31.25
48
20
16
40
32
80

25 lamps

301030

log $\frac{500}{25} = 20$ 7.698970

complog 40 8.397940

40 8.397940

25 8.602060

.01258 $\bar{3}.096910$

.00500 $\bar{4}.698970$

25 : 1

6 lamps.

log $\frac{500}{6}$ = 83.33+ — 1.920818

comp log 103.3+ — 7.985761

103.3+ — ~~7.985761~~

6. — 9.221848

...1301 — $\bar{3}$.114188

7 lamps.

781041
41
82

log $\frac{500}{7}$ = 71.4285+ = 1.853874

comp log 91.4285+ — 8.038918

91.4285+ — 8.038918

7. — 9.154902

1221 — $\bar{3}$.086612

8 lamps.

log $\frac{500}{8}$ = 62.5 — 1.795880

comp log 82.5 — 8.083283

82.5 — 8.083283

8. — 9.096910

...1146 — $\bar{3}$.059356

25 : 1

9 lamps.

578234
32
67

log $\frac{500}{9}$ = 55.55+ — 1.744731

comp log 75.55+ — 8.121733

75.55 — 8.121733

9. — 9.045757

1095 — $\bar{3}$.033954

11 lamps.

5990
32
42

log $\frac{500}{11}$ = 45.4545+ — 1.657582

65.4545 — 8.184057

65.4545 — 8.184057

11. — 8.758607

...964 — 4.184303

12 lamps.

log $\frac{500}{12}$ 41.666+ — 1.614475

61.666 — 8.209755

61.666 — 8.209755

12. — 8.920819

895 — 4.955204

25:1

13 lamps

13)500(38.4615
39
110
104
60
52
80
78
20
13
7

.000 865

log 38.4615 1.585027
comp log 38.4615 8.233130
38.4615 8.233130
13. 8.886057
26.937344
4.

log 500 = 2.698970
comp log 13 = 8.886057
1.585027
38.4616

14 lamps

log 500 = 2.698970
comp log 14 = 8.853872
1.552842

log x = 35.714 = 9.254032
comp log (20+x) 55.714 = 8.254032
(20+x) = 8.853872
14 = 4.914778

.000 821

15 lamps 25:1

500/15 = 33.33+ = 1.522879
comp log 53.33+ 8.279450
53.33+ 8.279450
15. 8.823909
4.905688

.000 804

17 lamps

log 500 2.698970
comp log 17 8.769551
1.468526
log 29.412 = 8.306167
comp log 49.412 8.306167
8.769551
4.849411

.699

5 : 1

1 lamp $\rho + r = 100$

log	500	2.698970
comp log	600	7.221849
	600	7.221849
.001388		3.142668

2 lamps

log	250	2.397940
comp log	350	7.455932
	350	7.455932
	2.	9.~~698970~~
.00102.0		~~7.555567~~
~~.000226~~		3.008674

4 lamps

log	125.	2.098644
comp log	225.	7.646853
	225.	7.646853
	4.	9.397940
.000617		4.790290

5 lamp

.000 500

000 500

5 : 1

8 lamps

log	125	2.096910
	225	1.647819
	225	7.647814
	8	9.096910
.000308		4.489448

10 : 1

1 lamp $\rho + r = 50$

log	500	2.698970
comp log	550	7.259637
	550	7.259637
.001653		3.218244

5 lamps

~~log 100~~ ~~comp log 200~~ ~~$\frac{1}{2000} = .000500$~~

~~10~~ lamps 5 lamps

log	~~100~~	=	2.
comp log	150	=	7.823909
comp log	150	=	7.823909
	5	=	7.301020
...889			4.948848

500

10 lamps

50.	7.798970
100.	8.
100.	8.
10.	9.
~~.000 639~~	4.798970
.000 500	

16 lamps 10 : 1

log 31.25		=	1.494850
comp log	81.25	=	8.090177
	81.25	=	8.090177
	16.	=	8.795880
.000 303			4.481084

25

25 lamps

log	~~200~~ 70	1.301030
comp log	80	8.221849
	60	8.221849
	25.	8.602060
		~~.045954~~
222		4.346988

50 : 1 $\rho + r = 10$

1 lamp

log	500	2.698970
	510	7.292430
comp log	510	7.292430
		$\bar{3}.283830$

.001922

5 lamps

log	100.	2.
	110.	7.958607
comp log	110.	7.958607
	5.	9.301030
	16.53	$\bar{3}.218244$

.001~~645~~

10 lamps

log	50	1.698970
	60	8.221849
comp log	60	8.221849
	10.	9.
		$\bar{3}.142668$

.001389

20 lamps

log	25	1.397940
	35	8.455932
comp log	35	8.455932
	20	8.698970
		$\bar{3}.008774$

.001020

50 : 1 $\rho + r = 10$ $l = 500$

~~4~~ 50 lamps

log	10	1
	20	8.698970
comp log	20	8.698970
	50	8.301030
		$\bar{4}.698970$

.000500

8 lamps

$\frac{500}{8} = \frac{625}{\cancel{6.450}}$

log	62.50	~~1.809560~~ 1.795880
comp log	7.25	~~8.127844~~ 8.139662
	7.25	~~8.127844~~ 8.139662
	8.	~~9.096910~~ 9.096910
		$\bar{4}.162158$ $\bar{3}.172114$

.001~~452~~ 1485

16 lamps

log	32.25	1.~~444850~~
	42.25	8.508530
comp	42.25	8.374173
	16.	8.374173
		9.795880
		$\bar{3}.055756$

.001135

250:1 $p+r = \$2$ $l = 500$

1 lamp

log	500	2.698970
		7.
complog	502	7.299296
	502	7.299296
		$\bar{3}.297562$
.001984		

10 lamp

log	50	1.698970
		8.
complog	52	8.283997
	52	8.283997
	10	9.
		$\bar{3}.266964$
.00 ~~1846~~ 18.49		

20 lamps

log	25.	1.397940
		8.
complog	27.	8.568636
	27.	8.568636
	20.	8.698970
		$\bar{3}.234182$
.001714		

50 lamps.

log	10	1
complog	12	8.920819
	12	8.920819
	50	8.301030
.001389		$\bar{3}.142668$

80 lamps 250:1

$\frac{500}{80} =$	6.25	0.795880
complog	8.25	9.083546
	8.25	9.083546
	80	8.096910
		$\bar{3}.059882$
..1147		

100 lamps

log	5.	0.698970
complog	7.	9.154902
	7	9.154902
	100	8.
		$\bar{3}.008774$
.001020		

125 lamps

log	4	0.602060
complog	6	9.221849
	6	9.221849
	125	7.903090
.000888		$\bar{4}.948848$

25 lamps
log 2

n^2 1000 : 1 $\rho + r = .5$

1 lamp

log	500	2.698970
comp log	500.5	7.300596
	500.5	7.300576
	.00 1798	$\bar{3}.300162$

50 lamps

log	10	1
comp log	10.5	8.978811
	10.5	8.978811
	50.	8.301030
	1814	$\bar{3}.258652$
	.00 1772	

100 lamps

log	5	0.698970
comp log	5.5	~~9.259637~~
	5.5	9.296707
	100.	8.2576 37
		~~3.242335~~
	.00 165.3	$\bar{3}.218244$

200 lamps

log	2.5	0 ~~602060~~
comp log	3.	9.377960
	3	9.522879
	200	7.698970
	.00 1389	27.142658
		$\bar{3}$.

250 lamps 1000 : 1 173

log	2	0.301030
comp log	2.5	9.602060
	2.5	9.602060
	250.	7.602060
	1280	$\bar{3}.107210$

400 lamps

log	1.25	0.096910
comp log	1.75	9.756962
	1.75	9.756962
	400.	7.397940
	.00 1020	$\bar{3}.008774$

500 lamps

log	1.	0.
comp log	1.5	9.823909
	1.5	9.823909
	500	7.301030
	.000 888	$\bar{4}.948848$

$\frac{1}{10}$ ohm

10 ft. long

$R = \frac{\text{Length}}{\text{Cross Section}}$ Constant

Cross Section $= \frac{\text{Length}}{R}$ ~~Constant~~ Constant

Cross Section $= D^2\pi$ in ~~.001~~ inches in.

Length in ft

R Constant = the resistance of 1 ft of wire .001 in in diam ~~etc~~ in Ohms

$$\text{Constant} = \frac{\text{Length}}{C \times R}$$

1760
3
5280

$$= \frac{5280}{\frac{\cancel{\pi} \times \cancel{.01}\,10}{.01\,\pi} \times 530.35}$$

that is 5280 ft of Cu wire in .01 in diam has a resistance of 530.35

log 5280. = 3.722634
comp log 31.41592 = 18.502850
" " 530.35 = 7.275436
18.
3.500920

∴ 3164.9 D in inches

.038 in. wire

$$\text{Length} = \frac{R \cdot \text{Cross Section}}{\text{Constant}}$$

$$R = \frac{\cancel{\text{Length}}\ 5280 \times C}{\cancel{R}\ \pi D^2}$$

3.722634
3.500920
comp. π 9.502850
.038 11.420216
.038 11.420216
39.566836
0

Ohm
.001

~~100~~ ft
~~200~~ ft
~~300~~ ft
400 ft
~~500~~ ft
600 ft
~~700~~ ft
800 ft
~~900~~ ft
1000 ft
1200 ft
~~1400~~ ft

$Q = \frac{l}{\pi D^2} C$

$\frac{\pi D^2}{4} = \frac{l}{R} c$

$\frac{D}{2} = \sqrt{\frac{l}{R\pi}} c$

$D = \sqrt{\quad}$ D in .001 in

C = length of line / C = resistance of line

.001 in in diam

C = resistance of 1 ft. of Cu wire .001 in in diameter

$C = \cancel{33.0,000}$ $\cancel{3.300}$ 10.3365

πD^2

πD
$2\pi R$
$\frac{1}{2} R$
πR^2
$\frac{\pi D^2}{4}$

$D = \sqrt{R} \sqrt{\frac{C}{R\pi}} \cdot \frac{100}{92}$

log 10.3365 = 1.014380
comp log .001 = 13. −10
comp log 3.141592 = 9.502850 −10
log 100 = 2
comp log 92 = 8.036212 −10
2 | 3.553442
~~0.357.6 in~~ = 1.776721

$D = 357.6$ ✓ = 18.91

$R_s : R_p :: \frac{1}{\cancel{92 \times 100}} \quad \frac{1}{100 : 92}$

$R_s = \frac{92}{100} R_p \quad \frac{100}{92} R_p$

100 ft 0.189.1 in
1000 1.891 in

1.1706 ft

110

0.068186
250
2 | 0.068426
0.034218
1.276721
1.309.39

20.46

55.02
2
110.0 4 0

~~1.276721~~
~~.036212~~
1.240509

1.776721
.036212
1.740509

$$R = \frac{L}{\frac{\pi D^2}{4}} C = \frac{4LC}{\pi D^2}$$

$$\pi D^2 = \frac{4LC}{R}$$

$$D = \sqrt{R}\sqrt{\frac{4C}{\pi R}}$$

C = Constant, the resistance of one foot Cu .001 in in diameter.

= 10.3665 Ohms for Lake Superior Cu multiplied by 1.692 / 1.673

.001 Ohm = R L = variable.

log.	4.	= 0.602060
log.	10.3365	= 1.01 4382
log	100.	= 2.
comp log	π	= 9.502850 —
comp log	.001	= 13. —
" "	92.0	= 8.036212 —

2 | 4.155504
2.07775
.036212
2.041540

1195

6.6465 / 2 | 0.781513
0.390756
2.041540
2.432296

270

11706 0.068436
2.041540
2.109976
128. .034218
2.075758
119.6

1.3931 2 | 0.143987
0.071993
2.041540
2.113537
129.9

.9675 2 | 1.985651
1.992825
2.041540
2.034365
108.0

.00155 2 | 3.190332 —
2.595166
2.041540
.636706
4.332

.0967
.16
5802
967
1.547

$$R = \frac{4LC}{\pi D^2}$$

$$L = \frac{\cancel{4}R\cancel{4}\,\pi D^2}{\cancel{4}C} = \frac{\pi D^2 R}{4C}$$

$$D^2 = \frac{4LC}{\pi R}$$

$$D = \sqrt{\frac{L}{L}}\sqrt{\frac{4C}{\pi R}} =$$

$$C = 10.3365$$

$$\cancel{1}1.5400$$

10.3365 ohms in 1 foot of .001 wire.

$$R = \frac{L}{D^2}\,C$$

$$D^2 = \frac{L}{R}\,C$$

$$D = \sqrt{\frac{L}{R}}\sqrt{C}$$

10.9

10.3365 ohm

1.014382
8.985618

.096744

$$D^2 = \frac{L}{R}\,C$$

$R = .001$
$C = 10.3365$
$L = .00155$

$$D = \sqrt{\frac{L}{R}}\,C$$

log 10.3365 — 1.014382
complify .001 — 13. — 10
4.014382

log .00155 — $\bar{3}.190332$
$2\,|\,1.204714$
.602357

4.00

$$(10.3365 \times 1.55)^{\frac{1}{2}} = \cancel{16}\ 4$$

$$\left(10.3365 \times \frac{.00155}{.001}\right)^{\frac{1}{2}} = 4$$

Log $\sqrt{\frac{L}{R}} = 2.007191$

log 6.0465 — ~~0.781505~~
2.788699
.390754

.250 — 2.397945

$\frac{C}{R}$ $\frac{100}{92}$ $R = .001$

log $\frac{C}{R}$ = 4.014382

log 100 2.

comp log 92 ~~1.963788~~ =
8.036211

4.050593

100 ft

2
2 ⟌ 6.050593

1.060 3.025296

---

200 ft 4.050593
6

$\bar{2}$.050593
4.301030

2 ⟌ .351623

7.509 .175861

---

300 ft $\bar{2}$.050593
2.477121

2 ⟌ .527714

1.836 .263857

400 $\bar{2}$.050593
.602060

2 ⟌ 0.652653

.326327

2.120

500 $\bar{2}$.050593
2.698970

= ⟌ .749563

.374781

2.370

600 $\bar{2}$.050593
2.778151

⟌ .828744

.414372

2.596

700 $\bar{2}$.050
2.845098

.895691

.447845

$R = \frac{L}{D^2} C$

$\frac{C}{R}$ $\quad \frac{C}{R}$ $\quad R = \frac{L}{D^2} C$

$C_{.001}$ = Ohms in one ft. .001 wire

$C_{1} = 1000\, C_{.001}$

$D = \sqrt{L} \cdot \sqrt{\frac{C_{.001} \div 1000}{R}}$ ~~in inches~~ in inches

.001

(for) $\frac{C_1}{1000} = C_{.001}$

Lake Superior

$\log C = 1.050593 \div 1000$

in .001 in.

$\bar{3}.$

$\log C = \bar{2}.050593$

in inches

R = equals resistance given

L = length variable

D = Diameter to be found

D.

100 feet $\log 100 = 2.$

Ohms	$\bar{3}.652653$	.6704
.00025	1.826326	
.0005	$\bar{3}.301030$	.43.71
	1.650515	
.001	3.050593	
	1.525196	.33.51
.002	2.749563	
	1.374781	.23.70
.004	2.448533	
	1.224266	.16.78
.01	2.050593	
	1.025296	.10.6
.02	1.749563	
	.874781	.07.49
.04	1.448533	
	.724261	.05.3
.1	1.050593	
	.525296	.03.35
.2	.749563	
1.	.374781	.02.37
	.025296	.01.06
2	$\bar{1}.749563$	
5.	$\bar{1}.874781$	.0074
	$\bar{1}.351623$	
	$\bar{1}.675811$	.0047

1 : 1 $\quad p + r = 500$

100 lamps

log 5. 0.698970
compting 505. 7.296709
7.296709
23.292488

$\bar{7}.292488$

~~.000000019961~~

.01961

$\frac{500}{750}$ $\frac{2}{1}$

750 : 1 $\quad p + r = .6666$

log. 500 = 2.698970 9491
500.6666 7.300445 57
666+ 7.300445 6
9554
~~.079460~~
$\bar{3}.299860$

75 : 1 2.698970 4665
57
cop. log 506.666 7.295274 6
506.666 7.295274 4726
$\bar{3}.289518$

1946

$$\frac{\frac{l}{n}}{\left(r + \frac{l}{n}\right)^2} = \frac{\frac{l}{n}}{r^2 + 2\frac{rl}{n} + \frac{l}{n^2}}$$

$$\frac{nl}{(nr + l)^2} \qquad \frac{l}{nl} = 1$$

$$\frac{1}{(r+1)^2}$$

$$\frac{1}{5} \qquad \frac{1}{(r+1)^2} = \frac{1}{\left(\frac{r}{2} + \frac{1}{2}\right)^2}$$

$$\frac{\frac{l}{n}}{\left(r + \frac{l}{n}\right)^2} =$$

50 lamps

$$\frac{l}{n} = 10 \qquad \frac{500}{50} \quad \frac{100}{100}$$

$$\frac{\frac{l}{n}}{\left(r + \frac{l}{n}\right)^2} \qquad \frac{l}{n} = 10$$

250 : 1

$$r = 2 \qquad 125.$$

$$\frac{10}{(2+10)^2}$$

20

$$\frac{x}{(y+x)^2}$$

$$\frac{\frac{l}{n}}{\left(r + \frac{l}{n}\right)^2} = \frac{\frac{l}{n}}{\left(r + \frac{l}{n}\right)} \qquad \frac{\frac{1}{x}}{\left(y + \frac{1}{x}\right)^2} = z$$

$$\frac{\frac{nx}{n}}{\left(ny + \frac{n^2}{n}\right)^2}$$

$$\frac{\frac{1}{n}}{\left(r+\frac{1}{2n}\right)^2} \qquad n = 10$$

$$\frac{\frac{1}{10}}{}$$

$$\frac{2n}{(rn+1)^2} = \cancel{\ldots}$$

$$r = \tfrac{1}{2}r'$$

$$\frac{2n}{(r'n+1)}$$

$$2n \qquad 2n = \frac{1}{2}n'$$

$$r = 2r'$$

$$\frac{\frac{1}{2}n'}{(r'n'+1)^2} =$$

$$\frac{\frac{1}{n}}{\left(r+\frac{1}{2n}\right)^2} \qquad \frac{\frac{1}{n}}{\left(r+\frac{1}{2n}\right)^2} \qquad \frac{\frac{1}{(.25)^2}}{} = 16$$

$$\frac{1}{(rn^2+n)^2}$$

$$rn^2+n = B$$

$$n(rn+1) = B$$

$$n = \tfrac{1}{2}n'$$

$$\tfrac{1}{2}n'(\tfrac{1}{2}rn'+1) = B \qquad \tfrac{1}{2}rn' = 2r'n'$$

$$n'(r'n'+1) = B \qquad r = 4r'$$

$$rn^2+n = B$$

$$\tfrac{1}{2}rn^2+\tfrac{1}{2}n' = r'n^2+n'$$

$$rn^2+2 = 4r'n'+4$$

$$rn^2 = 4r'n' = 2$$

$$r = 4r' = \frac{2}{n^2}$$

4000 : 1 $\qquad$ 2000 : 1

$n = 200 \qquad n = 100$

$$r = \frac{500}{4000} = \cancel{.0125} \quad .125 \qquad \frac{500}{2000} = .250$$

$$\frac{2.5}{(.125+2.5)^2} = \frac{5}{(.250+5)^2} = \frac{2.5}{\frac{(.250+5)^2}{2}}$$

2

$$\frac{\frac{b}{n}}{\left(r+\frac{b}{n}\right)^2} = \frac{2b}{\frac{(2r+\frac{2b}{n})^2}{2}}$$

$$= \frac{\frac{b}{n}}{\left(\frac{2r}{2}+\frac{b}{2n}\right)^2}$$

$$\frac{\frac{b}{n}}{\left(r+\frac{b}{n}\right)^2}$$

$$\frac{\frac{\ell}{n}}{\left(r+\frac{\ell}{n}\right)^2} -$$

$$\frac{\frac{1}{n}}{\left(r+\frac{1}{n}\right)^2} \qquad \frac{1}{\left(\sqrt{n}\left(r+\frac{1}{n}\right)\right)^2}$$

$$\frac{1}{\left(r\sqrt{n}+\frac{1}{\sqrt{n}}\right)^2}$$

$n = \frac{1}{2} n'$

$r = \frac{1}{2} r'$

$$\frac{\frac{2}{2n'}}{\left(\frac{r'}{2}+\frac{2}{n'}\right)^2}$$

$n = \frac{1}{2} n'$

$r = \frac{1}{2} r'$ #

$n = \frac{1}{2} n'$

$r = \frac{1}{2} r'$

$\sqrt{n} = \sqrt{2n'}$

$r = \frac{1}{2} r'$

$\sqrt{n}\, r = \sqrt{2n'}$

$n r = n' r'$

$$\frac{1}{2n'}$$

$$\frac{1}{\left(\frac{1}{2}r'+\frac{1}{2n'}\right)^2}$$

$$\frac{1}{\left(\sqrt{2n'}\,r'+\frac{1}{\sqrt{2n'}}\right)^2} =$$

$$\frac{\frac{\ell}{n}}{\left(r+\frac{\ell}{n}\right)^2} \quad \text{and} \quad r = \frac{1}{k}$$

$$\frac{\frac{\ell}{n}}{\left(r+\frac{\ell}{n}\right)^2} = \frac{\frac{\ell}{n}}{\left(r+\frac{\ell}{n}\right)^2}$$

$$\frac{\ell}{(nr+\ell)^2} = A \qquad n = 2n' \quad r = \frac{1}{2} r'$$

$$\frac{\ell}{(n'r'+\ell)^2} = B$$

500

$$\frac{\frac{\ell}{n^2}}{\left(\frac{\ell}{r}+\frac{\ell}{n}\right)^2} = \frac{\ell}{\left(\frac{\ell n}{r}+\ell\right)^2}$$

$$\frac{1}{\left(\frac{n}{r}+1\right)^2}$$

$\boxed{\frac{1}{75}}$

750

25	30
50	25
75	10
150	5
250	3
375	2

$\frac{1}{75}$

$\frac{1}{75}$ $\frac{1}{75}$ $\frac{1}{500}$

$$\frac{\ell}{\left(\frac{n}{r}+\ell\right)^2} \qquad \frac{\ell}{\left(\frac{n}{r}\ell\right)^2}$$

$$\frac{1}{\ell\left(\frac{n}{r}+1\right)} \qquad 75\overline{)750} \quad 10$$

$$\ell\left(\frac{1}{75}+1\right) = \frac{1}{\frac{76}{75}500}$$

$$= \frac{75}{76\times 500}$$

$$\frac{75}{76\times 500} \qquad \frac{750}{75}$$

$$\frac{1}{\ell\cdot\left(\frac{n}{r}+1\right)} \qquad r = 750$$

$n = 10$
$n = 15$
$n = 20$
$n = 25$

$n = 1$ $\frac{\cancel{500}}{\cancel{750\times 500}}$

$$\frac{1}{500\left(\frac{1}{750}+1\right)} = \frac{750}{500\times 751}$$

$n = 2$ $\frac{325}{500\times 326}$

$n = 10$ $\frac{1}{500\left(\frac{10}{750}+1\right)} = \frac{75}{500\times 76}$

comp log	500 =	7.301030	$\frac{1}{75}$
log	75	1.875061	
comp log	76	7.119186	
		$\bar{3}$.295277	.01973

$$\frac{\frac{\ell}{n}}{\left(\frac{\ell}{r}+\frac{\ell}{n}\right)^2} = \frac{\ell}{\ell^2\left(\frac{n}{r}+1\right)^2}$$

$\ell = 500$
$n = 10$
$r = 750$ $\frac{1}{75}$

$$\frac{1}{\ell\left(\frac{n}{r}+1\right)^2}$$

$$\frac{1}{500\left(\frac{10}{750}+1\right)^2} = \frac{.002\times 75^2}{76^2}$$

$\bar{3}$.301030
1.875061
1.875061
8.119186
8.119186
$\bar{3}$.289524

1948

$\frac{1}{30}$ $\quad \frac{.002830^2}{31^2}$

	$\bar{3}.301030$
	1.477121
	1.477121
	8.508638
	8.508638
.001873	$\bar{3}.272548$

$\frac{1}{150}$

	$\bar{3}.301030$
	2.176091
	2.176091
	7.821023
	7.821023
1973	$\bar{3}.295258$

$\frac{3}{500}$ log .002 log 500. complog 503.

	$\bar{3}.301030$
	2.698970
	2.698970
	7.298432
	7.298432
1976	$\bar{3}.295834$

$\frac{1}{80}$

	$\bar{3}.301030$
	1.903090
	1.903090
	8.091515
	8.091515
.001951	$\bar{3}.290240$

$\frac{1}{200}$ $\quad \frac{1}{500} \cdot \frac{200^2}{201^2}$

	$\bar{3}.301030$
	2.301030
	2.301030
	7.692804
	7.692804
	$\bar{3}.298698$ .1980

$\frac{1}{250}$

	$\bar{3}.301030$
	2.397940
	2.397940
	7.602326
	7.602326
1984	$\bar{3}.297562$

$\frac{1}{e\left(\frac{x}{r}+1\right)^2}$ $n =$ $r = 1$

$\frac{1}{e \times (n+1)^2}$ $\frac{.002}{25}$ $(n = 4)$

~~2000~~ 36 5

3.301030 5535
8.443696 ~~18675~~
1.744726

3.301030 6
8.309804 40.83
1.610834

---

7 3.301030
8.193820 31.25
1.494850

8+19 9.045757
9.045757 24.69
1.392544

9+1 10 3. 20.00
9.
9.
1.301030

10 compling 11 8.958606
8.958606 16.53
1.218242

11 compling 12 8.920819
8.920819 13.89
1.142668

12 8.886057 11.85
8.886057
1.073144

13 8.853872 10.2
8.853872
1.008774

14 8.823909 8.58
8.823909
0.948848

15 8.795880 7.812
8.795880
0.892790

16 8.769551 6.92
8.769551
0.846132

17 8.744727 6.173
8.744727
0.790454

18 8.721246 5.54
8.721246
0.743522

19 8.699670 5.
8.699670
0.698970

20 8.677781 4.535
8.677781
0.656592

25 compling 26 8.585026 2.956
8.585026
0.471082

Log

Table cost of E.L.

~~Added eight hundred and [illegible] in the [illegible] of the [illegible] only [illegible] before~~

Table i

Cost H.P. ½ ct. per hour

No. of Lts. per H.P.	Costs one hour	Aggr. 10 hours	annual 365 days	year 365 day
1	½ ct	5 cts	$1.50	$182.5
2	1/4	2½	$.75	$9.125
3	1/6 ct	1⅔ cts	$.50	$6.083
4	1/8	5/8 cts.	$.375	$4.5625
5	1/10	1 ct	$.30	$3.05
6	1/12 ct	5/6 ct	$.25	$3.041
7	1/14	5/7	$.214	$2.607
8	1/16	5/8	$.186	$2.281
9	1/18	5/9	$.166	$2.027
10	1/20	1/2	$.15	$1.825

365
5
5/3185
9125

365
4
3285

365
175
1825
2435
365
62675

365
125
1825
730
365
4562.5

365
225
1825
730
730
82125

log log log log

$W = L \times \text{time} \times C_w$

$L = 1$

$R = \frac{L}{a} C_R$

$C_w = \frac{W}{a} \quad \frac{189.07}{\frac{\pi}{4}(.25)^2}$

log

Conductors

Table continuing Sprague

1/8 in

Feet per Ohm

$R = \frac{L}{D^2} C$ $L = 1.000$ ft

$D = .25$ in

$R = .1654$

$\frac{.1654 \times (.25)^2}{1000} = C$

log .1654 = $\bar{1}.218536$

log .25 −

.25

10000000

.1000000

compl. log. 1.000 10.

$\bar{1}.218536$

$\bar{1}.397940$

$\bar{1}.397940$

$\bar{4}.14426$

$\bar{6}.0\,14426$

C = 0.0337

or 10336.5

$-\bar{1}.42$

$-((10-10+\bar{1}.42)$

$+(10-10+\bar{1}.42$

$\bar{11}.42\ \bar{10}$

$\bar{11}.42-10$

$R = \frac{L}{D^2} C$ $D = .25$

$L = 1$

$R = .1654$

$C = \frac{R D^2}{L} = R D^2$

log .1654 $\bar{1}.218536$

log .25 $\bar{1}.397940$

.25 $\bar{1}.397940$

$\bar{2}.014476$

10336.

.0337.

1000000

100

316

256

60

100

log C = $\bar{2}.014476$

256

23

0.14100

256

23

3/8 in log C = $\bar{2}.014399$

compl log .375 $\bar{1}$ 10. $\bar{1}.425969$

.375 10. $\bar{1}.425969$

$\bar{2}.866297$

R = $\bar{2}.866297$

compl. .125 $\bar{2}.014359$

compl. .125 10.903096

10.903096

$\bar{1}.820539$

6614

202

6.52
1.42 (10 − 1.42) = 10
10.58

3/8 .375 10.
comp .375 10.

1/2 comp log .5 10.
.5 10.

$R = \frac{L}{S} C$ $L = 1$
~~$S = .0625$~~

$R = \frac{L}{S} C$

$C = R S$ $R = .1654$
$S = .0490$

log .1654 $\bar{1}.218536$
.0490 $\bar{2}.690196$
$\bar{3}.908622$

810

203

$\bar{8}.014476 - 10$
$9.895090 - 10$
$\bar{3}.909566$
.0081202

$\bar{2}.014416$
$\bar{1}.895090$
$\bar{3}.909506$

log C_R
$R = \frac{c}{a}$ 189 $\frac{2.276462}{2.698066}$
3/8 comp log .1104 10.

1/2 comp log .1963 10.

Weight $= L \times a \times C_w$ 2.276522
$C_w = \frac{W}{a} = \frac{189.07}{\frac{\pi}{4}(.25)^2}$ 10.104910
10.602060
10.602060
$\log C_w =$ 3.585552
8461
91

$C_w =$ 3850.8

1/8 ~~comp~~ Log .0122 — $\bar{2}.086360$

4807 — 1.671912

comp log .0122 — 11.913640 − 10

~~18.499192~~

~~5499192~~

Conductivity Lake Superior

$\frac{092.57}{100}$ pure — $R = \frac{1}{C}$

$R = \frac{100}{92.57}$

3.909506
.033530
3.943036

2.
$\bar{3}.033530$
10.033530
0.033530

$R_p = \frac{L}{a} c$

$R_L \rho = \frac{100}{a_2} R_p$ — $C_L \rho = \frac{100}{a_2} C$

$W_p = L a C$

2 | 5280
2,640

3/8 Log .1104 — $\bar{1}.042969$ — Weight

Cost two 8.85. — $\bar{2}.628521$ — Weight

½ mile — 3.050125 — 425.22 — 1123.

comp log .1104 — 10.957031 − 10

Ohms per 1000 ft — $\bar{2}.900067$ — .0794

~~Ohms~~ feet per 1 Ohm — 1.099933+3 — 12584.

1/2 Log .1963 — $\bar{1}.292920$

189 — $\bar{3}.878472$ — cost 8.13 — 755.9

756 — 3.300176 — 1997.

~~185~~ — 10.707080 − 10

~~6.99~~ — 2.650116 — .06311

.118 — $\bar{1}.071920$ — 1.349884+3 — 22380.

5/8 Log .3068 — $\bar{1}.486855$

Cost two 8.236. — $\bar{3}.072407$ — 1181.

½ — 3.444011 — 3120.

comp log — 10.513145 − 10

.0754 — $\bar{2}.877785$ — 2.456181 — .02858

1.543819+3 — 34980.

3/4 Log .4417 — $\bar{1}.645127$

Cost two 8.340 — $\bar{3}.230679$ — 1700.

¼ — 3.652383 — 4490.

comp log — 10.354873 − 10

.0524 — $\bar{2}.719513$ — $\bar{2}.297709$ — .01986

1.702291+3 — 50360.

7/8 .6013 — $\bar{1}.779091$

Cost two 8.963 — $\bar{3}.364643$ — 2315.

½ ~~8.463~~ — 3.786247 — 6113

10.220909 − 10

.0385 — $\bar{2}.585549$ — $\bar{2}.163985$ — .0145

1.836055+3 — 68550.

1 inch .7854

~~755~~ 189
4 15
~~3020~~ ~~1134~~
.0293 ~~1134~~
~~3020~~
1 1/8 2.869549 .9940

.0232 $\bar{2}.366254$
1 1/4 1.227

.01882 $\bar{2}.275795$
1 3/8 1.484

$\bar{2}.203206$
1 1/2 1.767

.0131 $\bar{2}.117403$

$\bar{1}.895091$ 3024
3.480643 ~~2060~~
3.902247 ~~7605~~ 7984

10.104909-10 .01116
5.047945 89540.
4.952055
$\bar{1}.997386$
.58238 3827.
4.094542 10100.

10.002614-10 .008823
3.945650 113300.
5.054350
0.088845-10
3.674397 4724.
4.096001 12480

9.911155=10 .007148
3.854191 143100.
5.145808
0.191434-10
3.756986 5714.
4.178590 15.086

9.828566-10 .00591
3.771692 169100.
6.056874
0.247237
3.832789 .6892.
4.254393 17.580

9.752763-10
3 695799 .005692
6.304201 201.400

1 5/8 2.073

0.316599
3.902151 7982.
4.323755 21.170.

.0106 $\bar{2}.048041$
1 3/4 2.405

9.683404
3.626637 .001231
5.373563 236300.
0.381115
3.766667 9261
4.388271 24450

.0096 $\bar{3}.983525$
1 7/8 2.761

9.618585
3.561921 .003646
5.438079 274200.
0.441066
4.026618 10.390.
4.448222 28070

.00881 $\bar{3}.923574$
2 miles 3.141
~~154~~
~~84~~ 4.514224

9.558934
3.501970 .003176
5.998030 396.300
0.497068
4.082620 12100.
4.504224
~~4.925828~~
~~9.718672~~
9.502932
$\bar{3}.867571$ $\bar{3}.445967$ .002792
5.554033 358100.
comp log 5280 6.277366
1.831399 67.8 miles

$2\frac{1}{8}$ 3.546 ~~3.11759~~

0.549739
4.135291 — 13.970
4.556895 — 36030

9.450261
$\bar{3}$ 3.393297 — .002473

.00653 $\bar{3}$.814901
+ 1.5280 miles
$\bar{3}$.606703
1.884069 — 76.4

$2\frac{1}{4}$ – 3.976

0.599446
4.184998 — 15.310.
4.606602 — 40450

9.400554
$\bar{3}$ 3.943590 — .002205

.00588 $\bar{3}$.765194
5.656410
1.937776 — 85.85

$2\frac{3}{8}$ 4.430

0.646404
4.231956 — 17.056.
4.653560 — 45030.

9.353595
3.296631 — .00198

.00522 3.718235
5.703369
1.980735 — 95.6

$2\frac{1}{2}$ 4.908

0.690905
4.276457 — 18.900
4.698061 — 49890.

9.309094
$\bar{3}$.252130 — .001767

.00471 $\bar{3}$.673734
5.747870
2.025236 — 106.

$2\frac{5}{8}$ 5.411
Wt 1000 ft

0.733278
4.3 1 8830 — 20.840.
4.740434 — ~~4.166~~ 55010
9.266722 — .00162

.00427 $\bar{3}$.631362
$\bar{3}$.209758
5.790241
3.067607
0.978913 — 116.8
4.359265 — 22.870 ✓
4.780869 — 59.000

9.226287 — .001478
$\bar{3}$.169323 — ~~.00167~~
5.830677
2.108043 — 128.5

$2\frac{7}{8}$ 6.491

0.812312
4.397864 — 25,000. ✓
4.819968 — 65.980.

9.187687
.00 3573 $\bar{3}$.553327 — .001354
$\bar{3}$.131723
5.868277
2.145643 — 139.8

3. 7.068

0.849297
4.434849 — 27.220 ✓
4.836453 — ~~5.445~~ 71,850.

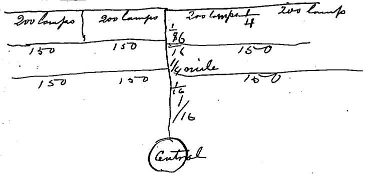
Cost 152. miles
.00327 $\bar{3}$.515338
2.906261 — 9.150702
4.434849 — $\bar{3}$.093738 — .00124
7.341110 — 5.906261
2.183627 — 152.6

5 | 21.930000
4,386,000

3½	9.621	0.983220	
		4.568772	36.780
		4990376	94810.
		9.016780	
		4.961816	.000915
		6.038184	
		2.318550	205.8
		3.383420	.00241
4	12.56	1.098990	48.360.
		4.684542	127600
		5.106146	
		8.901010	
		4.844046	.000609
		6.155954	
		2.433220	271.2
		3.265650	.00184
5¾	19.63	1.292920	75.400
		4.878472	
		5.300076	199.500
		8.707080	
		4.650116	.00446
		6.349884	
		2.627250	423.9
		3.071720	.00848

6	28.27	1.451326	
		5.036878	108.800
		5.454482	287.500
		8.548674	
		4.491710	.000 31
		6.508290	
		2.785656	610.1
		4.912314	.000817
10	78.54	1.895091	
		5.480643	302.400
		5.902247	798.500
		8.104909	
		4.047945	.000 111
		6.952054	
		3.227420	1695.
		4.469549	.000 394
12	113.6	2.055378	
		5.641930	438.000
		6.063634	1,155,000.
		7.944622	
		5.887658	.000077
		3.112342	
		3.389708	2452.
		4.309262	.000203

500 Ohms lamps.



500 1/10 Ohm to a lamp

Conductor maximum

500

1/10 Ohm to a lamp

Station

3/10 3/10

3/10 3/10 3/10 3/10 3/10 3/10

3/10 3/10

3/10 3/10 3/10 3/10 3/10

3/10 3/10

8)500 ~~4000~~ 3/10 3/10 3/10

3/10 3/10 3/10 3/10

3/10 3/10 3/10 3/10 3/10

3/10 3/10 3/10

3/10 Ohm 3/10 Ohm

3/10 Ohm

1/10 Ohm in each

1000 lamps

8)5.00 2/3

.0625

1/20 Ohm for each lamp

Maximum lamps

Conductor 1/10 total

Total resistance of conductor 1/10 machine 1/20

3.333 3.333 150 lamps

200 lamp 2.5 Ohms

at 1/2 mile

1

At $\frac{1}{2}$ mile 2640 $\frac{1}{2}$

1320 $\frac{1}{4}$

660 $\frac{1}{8}$

330 $\frac{1}{16}$

2640
2500
2000
1500
1320
1000
660
500
330
200
~~100~~
~~75~~
50
25

Size of wire
500

4000 : 1
3000 : 1

1/5 - 10 machines

10 | 500 lamps 50

20 | 500 25

10 lamps for
20 ~~H.P. Mach~~
5 H.P. Machine

25 lamps $6.57
10.
$16.57

Machine $100
10
1000

100
10
20
130

Wire 10

Lamps 20 $13

Cost if
5 lamps per H.P.
If 5 H.P. Machines cost say
$200
$ for each lamp $8 a year
80 cts
$6.57
.08
$6.57

Conductors 80

Serviceman

H

500 Ohm lamp

100 500

How do you do

Now is the winter of our
discontent made glorious
summer by this son of
York. Now is the winter
of our discontent made
glorious summer by this
son of York Now is
the winter of our discon-
tent made glorious summer
by this son of York
Now is the winter
of our discon-

500 Ohm Lamp

To figure out the resistance
and cost of the lamp

Now is the

Give me

500 Ohms in lamp

200 lamps at end

How do you find 2 s
you do you 2 bows 2 5 6 3 9 f
you you c

14 500
77 L
27000
1013
1013
1117

15.43 Grains in one Gramme
Sprague
1000 Grammes in one Kilo
7000 Grains in one lb.
15430.00 Grains in one Kilo
2.204 lbs. in one Kilo.

3.123851, 7 lamps reed =
1.513217
about 4 lamps white hot

6 — 60 miles
7 — 69 miles
70

10 — 60 / 70

7 miles land 6 miles sea

16 — 7 miles on land
2.5 — 6 miles
168

Fathom = 6 feet fath

640 acres in a mile

Acre 220 X 198 ft

Kilo 2.204

Litre .908 1.058

Metre 39.37 39.37
39.37

Hectare = 2.471

= 10000 metre² on a side

Are = a 100 metre square

Centare 39.37 100 H.P.

3.2808

328.08 on a side

220 X 198
220
3960
396
43,560.

33000 33000 33000 33000 33000 33000 33000 33000 33000 33000 33000 33000 33000 33000 33000 33000 33000 33000

4 acres

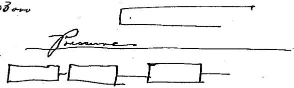
220 X 198 220 X 198 220 X 198
220 X 198 220 X 198 220 X 198
220 X 198
220 X 198 220 X 198 220 X 198

33000

220 X 198

33000

Pressure



300 Ohm lamp

~~10 lamps 30 Ohms~~

	Conductor
10 lamps	30 Ohms in Conductor & Man
20 lamps	5 Ohms in " " "
30 lamp	3.33
40 lamps	2.5
50 lamps	2
60 lamps	1.66
70 lamps	

Each lamp regulated as 2000' is to 1389 i.e. that when all ~~each~~ on the temp of each will be 1389 multiplied by a constant when only one it will also be 1389 X C but 1/3 of the time will be regulated away

~~150~~

1389 occurs when the No of the lamps is 1/5 of the No expressing the ratio of resistance in the lamp to that in the machine and conductor, or the No of times greater the lamp is the outside resistance

150 : 1

$\frac{500}{150}$ (3.33 — 200

300)500 (1.66 — 300

1 lb of coal 11.228 ~~000~~ ft lbs.

1 H.P. an hour for 10,

33000 / 60 = 550

~~1980000~~) 11.228 (~~000~~ lb.

11860

$\frac{1}{6}$ used

10 lamps 500 Ohms each

	Dia.	Area	Weight	Cost
100				
200				
300				
400				
500				
600				
700				
800				
900				
1000				

10 lamps 50 Ohms in all

20 Ohms in Machine and Conductors. 100 ft

1/5 in conductors 2.5 Ohm

~~1/40 in house~~ 1/20 in house

~~1/40 in street~~ 3/20 in street

~~.2 Ohms for house~~

.125 in house about .03 in diam

.375

$R = \frac{L}{D^2} C$ $D = \sqrt{\frac{L}{R} C}$

$D = \frac{L}{R} \sqrt{\frac{L}{R} C}$ $C = \frac{R D^2}{L}$

$L = 4$ ft

$R = 103.360$

$D = .001$

$L = 1$ ft

20
2.5
4.00

2.014383
3
3
4.014383

$$\text{Area} = \frac{\pi D^2}{4}$$

$$\text{Weight} = L a C \qquad L \text{ in } 1000 \text{ ft}$$

$$C = \frac{W}{La} \quad \text{(page 203)}$$

$$= \frac{3850.8}{1000}$$

$$\therefore \log 3.850 = 0.585552$$

Say 100 feet of conducting wire in each house then if there are 10 lamps in the house ~~and the res~~ that is when all on a resistance ~~of~~ of 50 Ohms

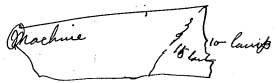
So that only 1/3 shall be regulated ~~for~~ away the resistance outside must not be greater than 20 Ohms[32] if ~~the temperature~~ no regulation occurs when all are on.

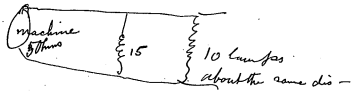
Then, ~~10~~ 10 Ohms outside.
In the machine 4/5 or 16 Ohms.

Take in ~~the~~ five lamps for horse power and five horse power machines 25 lamps

There ought not to be more the 5 Ohms in a machine for the ~~lighting~~ required

1/50 of an Ohm per lamp supplied if singly 25 lamps to a machine impossible





The lamps are all in multiple
are so the diagram is:

Inserting $1\frac{1}{5}$

$\frac{500 \text{ ohm}}{50 \text{ lamps}}$ 250 | 500 (2 ohms

250 of 1 2 ohms

If 50 lamps are to be used
the outside 2 ohms
100 lamps 1 "
$\frac{500}{500}$

10 lamps
$\frac{500}{50} = 10$ ohms
5 ohms

500

It is required that the resistance of all the lamps when in multiple are be five times that of all the outside conductors so that when all are

on the temperature shall give 1389 units of heat when if only one were on without regulating it there would be only about 999.5 degrees given off so that ~~about 1/5 would be~~ ~~to repair~~ it would be needful to regulate away about 1/3 when only one lamp was on.

---

10 lamps total resistance 50 Ohms

1/5 of 50 = 10 Ohms

---

n = no lamps

$\frac{500}{\frac{n}{5}} = \frac{100}{n}$ equals resistance outside

25 lamps from a machine ~~[illegible]~~ 1/5 Ohm to each lamp

---

50 lamps

2 1/2 Ohms in machine

1/5 Ohm to a lamp

$\frac{2.5}{50} = \frac{1}{20}$ Ohm 5 Ohm machine and 1/5 impossible!

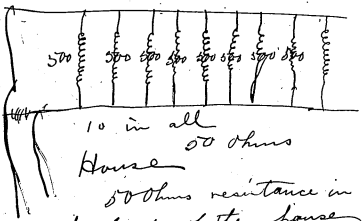
$\frac{100}{25}$ 4 Ohms outside

---

25 lamps from a machine of 2 Ohms

$\frac{100}{25} = 4$ 4 Ohms outside.

1/2 in machine



At an expense of ___ dollars 100 feet of ___ wire may be put in each house for conducting wire having resistance of ___ 1/4 in would cost $3.78.

R = .0165 Ohms

To the earth an equal amt making cost $7.56

R = .033 Ohms

The lamps in the house may

10 lamps may have $\frac{100}{10}$ 10 Ohms outside resistance so that

$\frac{1}{8}$ wire

say 250 feet

will cost ~~$9.45~~

R =

4 | .6615

.1654 Ohms

100 lamps in a house

5 Ohms

4 | 47.27

5 | 11.81

$2.36

96 | Book 31

288

122

2,204 lbs in Kilo

39.37 inches in Metre

220 X 198 ft in acre

6 feet one fathom

69 miles 60 and one mile

7000 grains one lb

If 100 lamps in one house

total resistance 5 ohms

R 250 feet 1/4 wire .1654

R Machine .5

.16654

Total resistance = 1.

Conductor .3346

or 1/3 in conductor or 1/15 of the resistance of all the lamps when in circuit in conductor.

100 Lamps must have only .3334 Ohms in conductor

100 feet away the conductor will have a diameter of — weight — and cost —

Constr RR Constr RR Cond

The is in each house a certain amount of wire which is constant if we think of the houses as units it can be seen that double the number of houses will half the resistance and proportionally to obtain the same effect the whole resistance must be half that is or the ars of machines and the cross section of the conducting wires must be doubled.

.3333 ohms

100 feet

$$R = \frac{L}{D^2} C$$

$$1 = \frac{L}{D^2} C \qquad L = 1$$

$$1 = \frac{C}{D^2} \qquad 1 = \frac{L}{D^2}$$

$$D^2 = \frac{1}{D^2} \qquad 1 = \frac{2}{D^2} \qquad \frac{L}{a}$$

$$W = L \cdot a \cdot C$$

$$\log C = \bar{4}.014383$$

$$\cancel{.000703} \quad \bar{2}.$$

$$.61032$$

$$D^2 = \sqrt{\frac{L}{R} C}$$

$L = 100$

$R = .3333$

$\log C = \bar{4}.014383$

$$\begin{array}{r} 2 \\ \bar{1}.522444 \\ = \bar{4}.014383 \\ 2\,\overline{)\,3.536827} \\ \hline \bar{2}.768413 \end{array}$$

.05867 in diam

$$\begin{array}{r} \bar{3}.536827 \\ 9.890970 \\ \hline \bar{3}.431917 \end{array}$$

.002703 area

$W = L\,a\,C$? = Page 224

$\log C = 0.5855552$

$L = 100$

$\log a =$

$$\begin{array}{r} 2 \\ \bar{3}.431917 \\ .5855552 \\ \hline .017469 \end{array}$$

0.41 lb

20 cts

1/2 miles 2)5280
2640

cost .20.

1.421604
2.843208
1.041 0.017469
2.860677

69 T.y
$139.

725
$145 for 1/2 mile 1/3 ohm

200 lamps

$1450 for 1000 lamps
at 1/2 mile distance
1/15 in conductor as in lamp
1/5 in conductor than in lamp
1000 lamps
that is 1/3 $462

1/4 mile $115
1/8 mile $29.

$600.000 Cost
60000 agent interest

50 ~~600~~
~~600000~~
60000
720 0
72
245500

1000 3 2000 200 200 2000
200

100 feet 100 lamps ~~[illegible]~~ ~~conductor~~ 1/15 of the resistance in the conductor than in the lamps or 1/3 Ohm.

A wire 100 ft long having 1/3 Ohm resistance will have a diameter of .05867 inches and a area of .002703

weighing 1.041

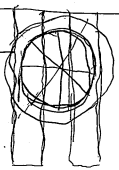
costing $1.208 20 cts.

---

200 ft

$$\frac{d(a^\theta)}{d\theta \log a}$$

$$\frac{d}{d\theta}\frac{a^\theta}{\log a}$$



$$\frac{a^{(\theta+\Delta\theta)} - a^\theta}{\Delta\theta} \qquad \frac{f(x+\Delta x) - f(x)}{\Delta x}$$

$$\frac{a^{(\theta+\Delta\theta)} - a^\theta}{\Delta\theta} = a^{(\theta}$$

$$\frac{a^{(x+\Delta x)} - a^x}{\Delta x} = a^{x+\Delta x}$$

$$a^x a^{\Delta x} - a^x$$

$$\frac{a^x(a^{\Delta x} - 1)}{\Delta x}$$

$$x = e^y$$

$$a^x = (e^y)^x$$

$$= e^{xy}$$

$$\frac{e^{z+\Delta z} - e^z}{\Delta z} =$$

$$e^{z+\Delta z} - e^z =$$

a a

$$e^{z+\Delta z} - e^z \quad e^z e^z \quad e^z e^z e^z e^z$$

$$e^{z+\Delta z} - e^z$$

$$\frac{e^{y+\Delta y} - e^{y}}{\Delta y} = e^{y}$$

$$\frac{a^{x+\Delta x} - a^{x}}{\Delta x}$$

$$\frac{a^{x+dx} - a^{x}}{dx} \quad \frac{dy}{dx} =$$

$$= a^{x} \log a$$

$a^{x} = e^{yx} = e^{y}$

$a = e^{y} \quad x = e^{y}$

$y = \log a$

$y = yx$

$\frac{dy}{dx} = y = \log a$

113
300
33.900
1728

11.

One Litre H weight 0.0896 Grammes

0.0896 Grammes,

1 Gramme H_2O

al 1.058 of H

log 1.1058 T.042600
log 0896 11.047692
.091292

1.23 litres
.61
1.84 litres

61.02 1.785751
1.84 0.264818
2.051569

11.3 cu in

34.462. 4.537340
.11058 1.043600
772. 2.887617
6.468557
33000 | 2914500 4.513958
1.954042

89.2

62.032 4.
.772. 2.
.11058 $\bar{1}$.6468557
.0022 $\bar{3}$.342423
36.771000

~~5.140 ft. lbs.~~ from one ~~Gramme~~ weight of H_2O formed.

47.887.000
.0002
9.577.4000

~~Factor~~ 62.032. 4.792392
772: 2.043600
.11058 $\bar{1}$.887617
.0022 $\bar{3}$.342423
4.066032

~~1.11400~~
11.400 ft. lbs energy in one pound of H_2O.
1/3 horse power to give 1.84 litres gas in one minute

If all the H. P.
were utilized 1.84 × 3
5.52

5.52 litres from one H.P.
a minute of mixed gases.
or 3 Grammes

5.52
60
331.20 litres an hour
About 331. litres
180 Grammes

Kilog. Meter,

24.577 — 4.390405
2.2046 — 0.342423
3.2809 — 0.515874
5.248702
174.000 — 4.518514
0.730188

5.4

1 Grain H

46.73 Cu. In.

46.73 1.669317

.11658 1.143370

4 .712687

215.16

2.58

7.84 cu. in. from a grain

480 grains = oz

7000.

3500.

46.73 H 9 Grains

53.

138

200

2138

1069

3227 cu inches from oz.

1728

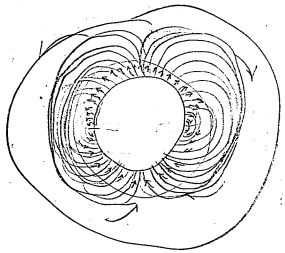
1

6

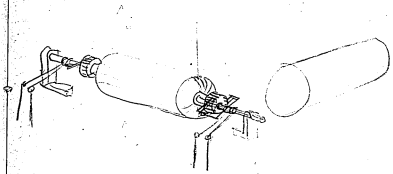
25 28

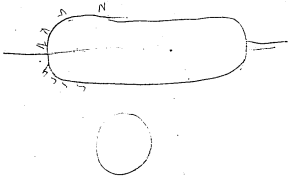
25 20

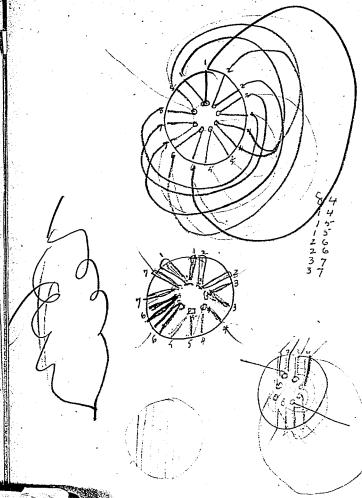
15

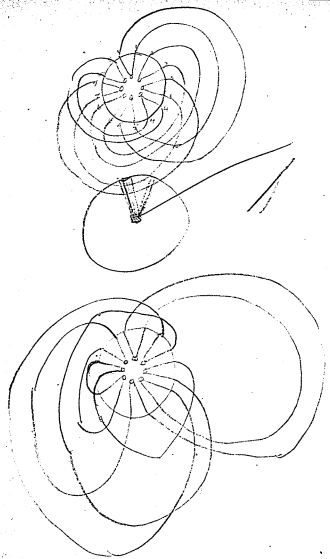


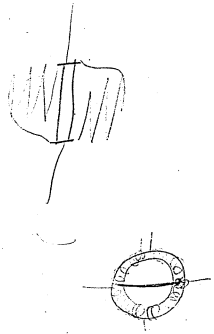
Pages 248 to 257."Dynamo Sketches." (Unimportant)

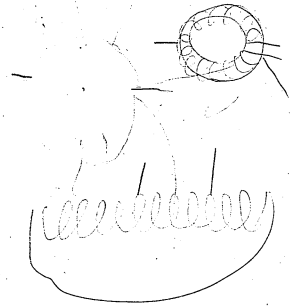












236
331
425
519
615
709
801
899
994
1088
1182
1279
1378
~~1390~~
1487
1574
1640
1746
1844
1940
2030
2130
2220

95
94
94
95
94
92
99
2 95
98
100
97
99
~~99~~
99
97
76
96
95
96
90
100
90

5718
4724
994

6800
5718
1082

7987
6800
1182

9261
7982
1279

10639
9261
1378

12096
10639
~~1390~~
1457

1.6744
15 1.1761
15 1.1761
4.0266

.13660 57
12096 13
1564

1.6744
17 1.2304
1.2304
4.1356
35

1366 3.2) 21.0 (.6
15310 798
13670 1.2
1640

17056 18900
15310 17056
1746 1844

2 | 5280
2.640
189.
499

.18
0.4216
2.2765
2.6981

4 | 498
124.5
9
1120

2.0951
.9542
3.0493

4490
4
17,960

6113
4
24,452

2.0958
13 1.1139
1.11139
4.3236

2107
2.0958

125 | .8 57
.75 | .0934
3.14 | .9977
1.4661

2925
Upton

Jan 14 1879

Jan 20. 2 no estimate
100 / 1000

10 Hour 1 cent

About the cost of 1 H.P.
per hour according to an
estimate furnished Mr
B. from Manchester

The Heating value
of gas is about
[illegible]

$\frac{3}{32}$

.10

3.14

.314
.75
1570
2198
.23550

.125
.75
.625
875
9375
3.14
37500
9375
251.25
29.43750

5.70

Orica Spirals .2.3
4.3 Spirals to an inch

Spiral grave
2.5 Candles
4.3
7.5 Jan. 14. 1879

Shorter afterwards

3 red bright
4 ~~yellow~~ reddish yellow
5 yellow
6 yellowish white
7 white
8 full white
9
10
11
13 reduced
14 melted

.125
3.14
.75
Log. 2.9

0 7.096
0.496
7.875
7.467
~~.0.23~~

.23) 1.00 (4.3
.92
80

1.480
.378

Edison Laboratory Note Book. No. 12.

Pages 221 to 280.

Notes on Platinum & other Metals & Potassium oxide

See Edison Patents:

214,656	224,229
227,228	218,905
227,227	227,229

Area Spiral .23
4.3 Spirals to an inch

Spiral gave
2.5 Candles
4.3
7.5 Jan. 14. 1879
10.0
10.75 for an inch

5.5 & 5

0.740	.929
0.740	.929
.480	1.858
	1.480
	.378

.23) 1.00 (4.3
.92
80

Shorter spirals

3 red bright
4 ~~yellow~~ reddish yell
5 yellow

1.5
1.4 melted

.125	0.096
3.14	0.496
.75	1.875
Cog. 2.9	1.467

~~.0.23~~

$L : C :: (7.25)^2 : (4.75)^2$

Candle	Lamp
4.75	7.25
.677	860
.677	860
1.354	1.720
	1.354
	.366

2.4

Spiral wound on white clay

Spiral color of

3 cells red

4 " full red

5 " reddish yellow

6 " yellow

7 " bright yellow

8 " yellowish white

9 " white with shade of yellow

10 " white in candle light

11 " full white

12 " white

13 "

14 " 2 candles [illegible]

.010 Iridium } Spiral 10pc
Platinum }
Resistance 3.7

3 Cells — Red —
3 lines Inside the last
spiral turn

4 Cells full Red
5 Cells Reddish Yellow
6 Cells Yellow
7 Cells Whitish Yellow
8 Cells Yellowish White
9 Cells White tinged yellow
10 Cells White
11 Cells full White
Bright White
12 13 Brilliant White 14 Intense White

12

270

Platinum Wire .004

Cold on 1 Cellars Cell 6'1

resistance 350 m m

2 Cells Carbon Full Red

3 —— Rich Yellow

4 —— Bright Yellow

5 —— White

6 —— Brilliant White

7 —— Melts

4 Cells
Color Bright Yellow
Defec – 8 —
Resist 10"

5 Cells
Color Yellowish White
Define
Resist

20/170 = 1.2

170 : 150 :

180

150 : 10.5 : 180
105
00
180
180
0.06
1576
0
12.6

Platinum wire .004 Feb 14 1919

14 cells

" 170 m.m. Melts Chas Lechler

180 m m. Deflection 21 12 ohms

Scarcely any permanent elongation

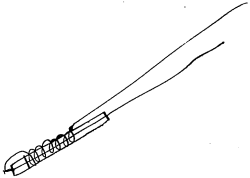
Platinum Iridium 20%

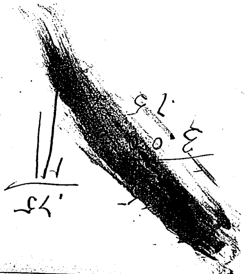
1 Cell

Deflection 3½

Resistance 6.4

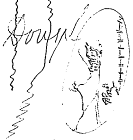
2 Cells	3 Cells
Color Red	Color Yellow
Deflec 6½	Deflection 7
Resistance 6.7	Resistance 9.2





14° —

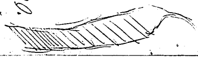
Dougmet



15½	– 7.9
16½	– 8.3
17½	– 8.74
18½	– 9
19½	– 9.2
20½	9.5
21	9.9

	dif.	Resist
.004 = 1 cell	= 5Ω	= = 8 4
= 2 "	= 8½	= = 4.9
= 3 "	= 11	= = 5.7
		6.5

14



$$D = \frac{E}{B + R + S} = \frac{E}{B + \frac{(R S S)'}{R + S + S}}$$

$$= \frac{E}{B + \frac{S + S + S}{R (R + S)}}$$

$$\therefore B + \frac{S - R + S}{R (S + S)} = B + R - S$$

$$S + R - S = R$$

Size of Wire 1
Length of wire 2
No. of Coils 3
Deflection 4 Chas Bachelor
Resistance 5 Chas Bachelor
Defle^{n} X Resis. 7 Chas Bachelor
Ratio to Current ^{2}X R coils. 8
Ratio when coils used 9 8.43 6.1
Remarks 10
Color 6 8.5

Chas Bachelor

Chas Bachelor 8.9 6.9 11

Chas Bachelor 9.2 6.1

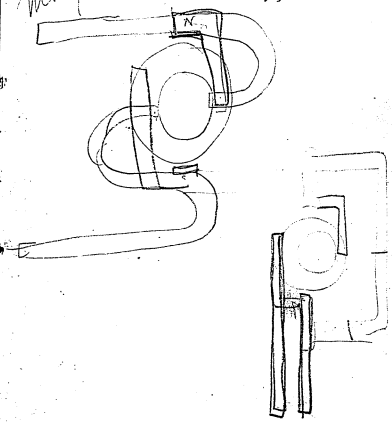
Chas Bachelor

10.5

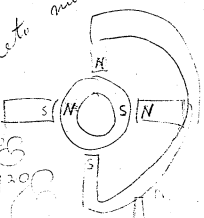
18 Ratio

026

Magnetic Induction

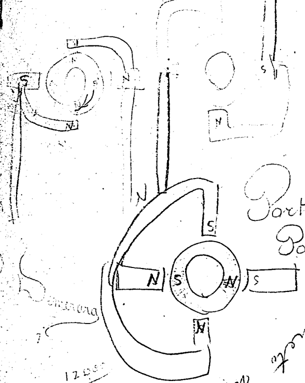


Magnetic multiplier



$2\frac{1}{2}$

190 200 / 10 / 2000



Portland

Portland

Demerara

12000

120,000

120.000

Demerara

Demerara

.8 per ton = 1.92 / 365

24

1.92

8 8

19.2

576

960

1152

576

700.8

700.8

Demerara

Demerara

1/16

1/8 4

1/4 16

1/2 64

1 256

2 1024